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NASA/DoD/DoE Aerospace Pyrotechnics Systems Steering Committee

Minutes:
Seventh Meeting

NASA Langley Research Center
December 8-10, 1992

Chair: Norman R. Schulze
NASA Headquarters
Washington, DC 20546

(NASA-TM-111164) NASA/DOD/DOE AEROSPACE PYROTECHNICS SYSTEM STEERING COMMITTEE. MINUTES: SEVENTH MEETING (NASA) 187 p

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MEETING MINUTES

Seventh NASA/DOD/DOE Aerospace Pyrotechnic Systems Steering Committee

NASA Langley Research Center

December 8-10, 1992

I. INTRODUCTORY REMARKS

The NASA/DOD/DOE Aerospace Pyrotechnic Systems Steering Committee met at the Langley Research Center (LaRC) on December 8-10, 1992. Representatives from all NASA Centers, except the Marshall Space Flight Center and the Ames Research Center (via the Dryden Flight Research Facility representative), were present at this Seventh meeting, as were the Air Force and Department of Energy. (Attachment 1)

Mr. Norman Schulze, the Committee Chairman, gave introductory remarks. He thanked Dr. St. Cyr and Mr. Wittschen for the rapid publication of the proceedings of the First NASA Aerospace Pyrotechnic Systems Workshop (NASA Conference Publication 3169). He acknowledged the Pyrotechnic Manufacturing Safety seminar to be held in Long Beach, California in late January and invited members to join the AIAA Ordnance Working Group. Application forms are provided. (Attachment 2) The International Pyrotechnics Society was discussed by Mr. Schulze who noted that Mr. Laib is a member. The constitution of the International Pyrotechnics Society is provided as Attachment 3. Mr. Schulze introduced Mr. Larry Rayburn, representing Kennedy Space Center (KSC). The Committee has a new organization included in the membership, the Naval Research Laboratory, represented by Mr. Mark Frata or Mr. Bill Purdy. The NRL was unable to attend this meeting due to a program review requiring their participation.

Mr. Robert Swain, Director of Engineering at LaRC, welcomed the Committee. He noted that Langley is celebrating its 75th year of operations, the oldest NASA installation. The staff of 2900 civil servants plus 2200 contractors is mostly professionals with a significant number of technicians and craftsmen. Langley works in selected areas of astronautics and space science. Aeronautical research comprises their primary function accounting for about 70% of their effort. This is a reversal of prior program commitments where the emphasis was on space. Langley has changed its emphasis back to basic research after having successfully performed the Viking Program. An example of a more recent significant space project was the Halogen Occultation Experiment (HALOE) that is now flying on the Upper Atmospheric Research Satellite (UARS).

Mr. Swain stressed the importance of this NASA pyrotechnic activity encompassing the program and the Committee activities. Because there never has been a program of this nature, the dividends to the government offer great leverage. He has a personal interest in the pyrotechnics technology. He was a member of the original Rocket Group at Langley which conducted research on propulsion and pyrotechnics. He managed the launch of a variety of small scale solid propulsion vehicles and supported the Scout vehicle. He noted that the pyrotechnic technology can have serious safety consequences as proven by a fatal accident on the Delta launch vehicle payload in the mid-60's which resulted from an inadvertent electrostatic ignition of the Antares X-248 motor. Because of the accident, improvements were implemented in initiator safety, leading up to the 1 amp-1 watt minimum no-fire design cartridges, now in wide use. He noted that pyrotechnics devices have played an important role in programs at Langley, and he has supported pyrotechnic technology development.

Mr. Schulze reviewed the agenda (Attachment 4), distributed the Committee Charter (Attachment 5) and asked the members to update information contained in the draft roster of pyrotechnic personnel. Several minor changes were suggested, but the opinion of the Committee was that the Charter was still equally applicable. He discussed whether there is any interest in publishing an "Aerospace Pyrotechnics Systems Newsletter." The Committee expressed the desire to have the newsletter. Any items of interest should be reported to Mr. Schulze for inclusion. He discussed the presentation material in Attachment 6.

The primary meeting objectives were to review the program and to determine the Committee goals for the future.

Reporting on the status of events at Headquarters, Mr. Schulze discussed the latest organization and programmatic changes at Headquarters and in Code Q. NASA, using a red-team, blue-team approach to evaluate major programs, has undertaken a major reorganization following the Administrator's request. Code S, the Space Science Office, has been divided into two separate offices, "Mission to Planet Earth" and "Office of Planetary and Astrophysics" and Code R into two separate offices, one for aeronautics and the other for space. [Code S has, subsequent to this meeting, been divided into three offices.]

A red-team, blue-team approach was also initiated by Code Q to evaluate its programs. One result of the Code Q red-team, blue-team activity was that the NASA Aerospace Pyrotechnics Program along with the other hardware applied technology programs were considered as activities that should be supported by other codes. Consequently, the Technical Standards Division, Code QE, within the Office of Safety and Mission Quality, is substantially reducing the scope of the Pyrotechnics Program. Mr. Schulze met with staff from Codes C, D, and M to request their support. While they agreed with the need for the pyrotechnic activity, none felt that they could undertake any funding support.

Code QE, as a result of the red-team, blue-team activity has greatly reduced its support for hardware development programs. The Code Q focus will be on the development of safety, reliability, and quality assurance policy, specifications, and manuals, rather than on hardware activities. The Code Q office has reviewed the reorganization with each of the centers and the change in focus of the Code Q roles and missions.

On the subject of travel to the Committee meetings, which is a problem for some members, he reported that he found no means to provide travel funding for either NASA or non-NASA members. He stated that this situation was particularly a problem with the Navy representative from White Oak where support of activities outside of those relating to sponsors was particularly difficult in view of current local and national events. He requested that any individuals having a travel problem identify their difficulty. The preferred time to meet was early in the fiscal year, the dates after mid-year being progressively worse. Two meetings are desired, one being in conjunction with the Workshop.

Mr. Schulze described some research opportunities for pyrotechnics that were included in the most recent solicitation for the NASA Small Business Innovative Research program to which contractors can submit proposals for evaluation. These programs are managed by NASA centers. Members were encouraged to pursue the SBIR for projects. Those who are interested in this funding approach are requested to contact Mr. Schulze for further information.

A "Technical Transfer Award of Excellence" is being initiated by Headquarters to reward centers which exhibit the strongest and most successful efforts to transfer technology to the

United States industry. NASA is placing considerably greater emphasis on technology transfer in the United States. Planning is complete and is under review for initiation either in 1993 or 1994. (Attachment 7)

II. GENERAL DISCUSSION

Mr. Schulze invited all Committee members to describe recent developments at their installations. Suggested topics were the status of major programs, new development programs, current issues, problems, and recent failures.

A. Johnson Space Center (JSC).

Mr. Wittschen reported that JSC had acquired an engineering workstation and is using it to run pyrotechnic modeling software provided by Sandia. The detonator and booster for the 2.5 inch frangible nut will be analyzed first. A new docking mechanism is needed for the proposed Shuttle mission to the Mir space station. It will have many pyrotechnic devices. JSC is considering the Soyuz capsule for the Assured Crew Return Vehicle (ACRV). The Soyuz has a few hundred pyrotechnic devices with a design life of 0.5 year rather than the 3-5 years needed for the ACRV. Another recent study considered the common lunar lander for the first lunar outpost. Refurbishment of Orbiter pyrotechnic devices was postponed because the test results from Langley demonstrated that the original devices had a 15-year life, five years longer than previously allowed.

B. Lewis Research Center (LeRC).

Mr. Seeholzer told the Committee that the linear separation system between the Mars Observer and the Transfer Orbit Stage worked well. The Committee's early work contributed to the design improvements used in this system. The same system will be used for the Advanced Communications Technology Satellite and Cassini.

C. Wallops Flight Facility (WFF).

Mr. Hickman noted that WFF is involved in launch operations for Commercial Experiment Transporter (COMET) and Brazilsat which use small commercial launch vehicles. COMET is the first flight of a launch vehicle developed for NASA's Centers for the Commercial Development of Space. COMET provides about 30 days for microgravity experiments and then returns samples to the Earth for evaluation. Brazilsat is the first East coast launch for the Pegasus booster. It carries Brazilsat to orbit from which it will monitor the environment of that tropical nation. He noted two recent problems: an ordnance system with 0.5 inch gaps rather than the 0.25 inch standard and malfunctions with an exploding bridge wire controller for a flight termination system. He also suggested that the Committee have a representative from the Goddard Space Flight Center, the parent organization for WFF. That representation will be beneficial to GSFC projects.

D. Aerospace Corporation.

Mr. Gageby will revise DOD-E-85378A, General Specification for Explosive Ordnance for Space Vehicles, during 1993. Another goal is a "standardized" laser safe and arm system. A student intern at Aerospace has started modeling a pin-puller used on DOD weather satellites. He continues to be concerned with pyrotechnic system performance on Pegasus and an Air Force launch vehicle. Pegasus had some ground test failures and incomplete in-flight stage separations. Test results were not reproducible for an exploding bridge wire system used on a proposed upgrade for an Air Force launch vehicle.

E. Jet Propulsion Laboratory.

Mr. Agajanian reported that the recently launched Ocean Topography Experiment (Topex) spacecraft successfully deployed its booms using JPL-developed pin-pullers. The primary instrument on this mission to study global ocean circulation is a microwave radar altimeter with some long antenna structures. JPL is also working on a similar NASA scatterometer (NSCAT) that will fly on a Japanese satellite. JPL is working with universities and foreign institutions involved in building instruments for the Cassini mission that will send an orbiter and probe to Saturn. Mr. Agajanian described the Mars Environmental Survey (MESUR) program (Attachment 8). He is advocating the use of laser-initiated pyrotechnics to the subsystem designers.

F. Department of Energy.

Mr. Harlan sees an opportunity for laser systems as replacement hardware to extend the life of existing weapons systems. Producing hardware qualified for very demanding operational environments is the focus of his work. Sandia has demonstrated a laser diode system firing through a 1000-meter fiber for disposal of old pyrotechnic materials. He reported that Sandia obtained 12 W pulses from a laser diode array; this approaches the level needed to replace rod lasers with diodes. DOE is trying to improve technology transfer to the private sector and wants to work with NASA. [He met with Col. Gregory, Associate Administrator for Safety and Mission Quality, in February 1993.]

G. Langley Research Center.

Mr. Bement described the following pyrotechnic subsystems in the LaRC design concept for the Mars Environmental Survey (MESUR) aeroshell: capsule release, capsule despin, aeroshell release, parachute release, and parachute jettison. (Attachment 9) LaRC and McDonnell-Douglas will seek a patent for a new aircraft canopy fracture system. His ignitability test methods will be applied to the primers for 20 and 30 mm shells. He would like to do more work on explosive transfer lines to determine the cause of some rare failures the Air Force had at the end fittings.

H. Naval Research Laboratory (NRL).

Attachment 10 presents a description of the NFL's activity and one project of interest.

I. General discussion.

The consensus was that the Committee had much experience to offer their respective agencies. The concern is how the Committee can best make staff aware of its presence and talent which would be useful in assisting programs. One suggestion was that contact should be made with the center Engineering Management Council member. Other ideas were solicited.

III. PAS PROGRAM STATUS

As explained by Mr. Schulze, manuals, modeling, and the PAS data base will be the new focus of Code Q, following the Code Q red-team, blue-team activity. The Pyrotechnically Actuated Systems program has been revised to reflect a substantial reduction in the program in FY93 from $900K to $250K and will support basically the data base in FY94. The changes resulted from the Code Q red-team blue-team review activities from which a decision was made to reduce support for Code Q hardware-focused programs. Currently funded projects will be completed. The laser safe and arm specification is still planned.

Mr. Schulze reported that the project to demonstrate a laser safe and arm system in flight aboard the Pegasus flight vehicle is being considered for contractual implementation under the value engineering approach. The objective remains to fly this system in 1993 or early 1994 after the contractual issues have been worked.

Committee members expressed concern about the Code Q changes resulting in program phase out after there had been such wide support in 1987-88 from all the NASA centers and DOD as well as from senior NASA Code Q management. The Committee stated that they should brief the new Code Q management as had been done in 1988 for Mr. Rodney, Associate Administrator for the Office of Safety and Mission Quality, to describe the serious nature of the problems encountered over the past 23 years and also on the recommended resolutions as reflected by the Pyrotechnics Program Plan. Also discussed was the possibility of presenting briefings to other Headquarters offices. The recommended approach was to advise the Engineering Management Council (EMC) of the nature of the problems and the significance of the Pyrotechnic Program. Each Committee member should brief their EMC representative. Mr. Bement recommended that the Committee go to the other Headquarters offices with support from the EMC. It was considered important, as a minimum, for the program to present the annual report to the Code Q Associate Administrator and Code QE Director as had been planned in the approved Program Plan. Several letters were presented to the Committee that had been written by industry discussing the importance of the program. (Attachment 12)

The project managers were requested to report on program accomplishments, status, and remaining plans considering the downscoping. (Attachment 11)

A. Project 1.3 - NASA Pyrotechnic Specification.

Mr. Wittschen explained that given the result of the recent decision to downgrade the specification for the NASA Standard Battery to a guideline or checklist document, there is a question on the direction of Task 1.3 and whether it, too, should be written as a guideline document. The Pyrotechnic Specification is being drafted by Mr. Les Wynn of Lockheed Corp. under contract to JSC. Mr. Wynn distributed copies of a "discussion draft" of the document intended as instructions for writing program specific specifications. The document includes references to other NASA documents and definitions of technical terms. The basis for the Pyrotechnic Specification is NSTS 08060–Space Shuttle System Pyrotechnic Specification, the specification for the NASA Space Shuttle Program. The specification has technical requirements for design, development, manufacturing, qualification, and acceptance. Flight safety and mission quality requirements have been included. The document provides only references for range safety and ground handling safety. The section on testing addresses developmental testing, non-destructive testing, and qualification tests. The discussion of performance tests covers quantitative test methods for a variety of devices. Performance margin tests are required for development and qualification but not for lot acceptance. The document requires that test parameters be defined carefully.

Mr. Schulze explained that the intent of this project is to assist program engineers in the accomplishment of their pyrotechnic job functions and to foster uniformity in NASA's procurement of pyrotechnic devices and systems. He asked members to comment on the document as presented.

A poll of the Committee provided general agreement that NASA needed common guidelines for pyrotechnics that could be tailored for specific applications.

The members expressed concern that a NASA Handbook would eventually cause the imposition of requirements on users that may not be appropriate. Mr. Wittschen noted that because JSC's main job is the Shuttle and because they use NSTS 08060, they do not need this document. Space Station Freedom (SSF) has not recognized that there will be pyrotechnic devices used in that program, a situation similar to the Shuttle many years ago. He also pointed out that to incorporate requirements for automated spacecraft and aircraft is a significant task and asked whether this need should be included in the document. Mr. Schulze asked all members to provide comments on this discussion draft, including a response to the question of including automated spacecraft and aircraft, to JSC by the end of March. This project has now been fully costed.

B. Project 1.4 - PAS Database and Catalog.

The purpose of the PAS Database (Attachment 13) is to make all pertinent design, test, and certification data for existing pyrotechnic devices available throughout NASA and other interested organizations. The PAS Catalog will present selected data in the database. LeRC has received no responses to the printed and electronic versions of the database questionnaire sent to all NASA filed installations. Mr. Schulze asked LeRC to call each installation to find out when to expect a response. The Committee agreed that the database should include a bibliography of pertinent publications.

C. Project 1.7 - Pyrotechnic Manual.

Mr. Bement presented a proposed table of contents (Attachment 14) for the pyrotechnic manual. The manual, much like a textbook for Charts a continuing education course, will present the best engineering practices for pyrotechnic devices and systems. The members expressed strong support for the manual and in the content as presented by Mr. Bement. There is some rationale for incorporating the information which has been prepared for the specification into the manual. Members are requested to provide a feedback on their opinion to Mr. Schulze.

D. Project 2.1 - NASA Standard Gas Generator (NSGG).

Mr. Bement presented the test results from a feasibility study that employed several different test procedures to measure both the pressure and energy output. These results (Attachment 15) show the superiority of adding gas generating material to the basic NASA Standard Initiator (NSI) design. He outlined a plan for the acquisition of 50 to 70 NSGGs from two sources. Reduced funding for this project limits the lot size. These devices would be used for conducting a delta-qualification with energy output determinations after environmental exposure compared to as-received performance. Groups of devices would be exposed to temperature, vibration, mechanical shock, and thermal shock environments as applied in the recent NSI delta qualification program. Mr. Bement expects to complete the work in this project by September 1993.

E. Project 2.2.1 - Linear Separation System.

Mr. Agajanian described a JPL study (Attachment 16) to model linear separation systems using a modified Air Force hydrodynamic computer code. The code was adapted to run on a 486 personal computer and gave promising results for a two-dimensional model of a common linear separation system. Further progress is impossible because of a lack of trained personnel. After some discussion, a hydrodynamic code from Sandia appeared to be a better option than a transfer of the JPL work. Mr. Harlan and Mr. Davis are to coordinate. Mr. Bement proposed termination of the Pyrotechnic Program's joint MSFC/JPL/LaRC test plans for developing a Standard Linear Separation System due to lack of funds resulting from termination of the program. Also, he proposed that unused funds be applied to the completion of the NSGG project. The Committee endorsed Mr. Bement's recommendation.

F. Projects 2.4 and 2.5 - Laser Safe and Arm System/Laser Initiated Detonator.

Mr. Wittschen reported that this project provides partial support for the development of an all solid-state safe and arm system. The flight demonstration on the Pegasus expendable launch vehicle now is scheduled for early 1994. Attachment 17 presents the schedule. The first operational flight for NASA is the Total Ozone Mapping Spectrometer (TOMS) mission in December 1994. NASA Goddard Space Flight Center is exercising a contract option on an existing Pegasus procurement for the flight unit and for 150 laser initiated detonators for test at JSC. JSC has ordered three laser firing units that will be used for supplemental testing to support range safety needs. JSC expects GSFC to give final contract approval soon and to hold a kickoff meeting with Ensign-Bickford, anticipated [at the time of this Committee meeting] to be in January.

G. Project 3.6.1 - Service Life Extension.

Mr. Bement reported that JSC sent Space Shuttle pyrotechnic components removed from Columbia during its recent refurbishment to LaRC for testing. The devices performed within specification requirements (Attachment 18). Units that never flew in space, but which had a shelf storage life of 15 years, also met specifications. The chemical analyses of the two groups were similar. These test results allowed JSC to postpone replacement of the pyrotechnic devices in Atlantis by 5 years, a significant cost avoidance. Devices removed from Discovery will go to LaRC for additional tests that may allow a 20-year life.

H. Project 4.2 - Modeling of the NSI Driven Pin Puller.

Dr. Stubbs of Lewis Research Center (LeRC) introduced Dr. Powers of the University of Notre Dame, the Principal Investigator for this project. The purpose of this project is: given a set of inputs, how does an engineer design the intended product? Since the last meeting, Dr. Powers used the model to predict experimental data and for a sensitivity analysis. The preliminary model assumes a constant volume that is spatially homogeneous and employs equilibrium chemistry. The model does not include the NSI burst diaphragm or the two levels of propellant density introduced by the manufacturing process. Temperature dependent specific heats come from the "CHEMKIN" data base. The model has a coupled equation of state that balances mass and energy and has a combustion model for gas generation rates. See Attachment 19 for a more complete description of the model's assumptions and principals, and a complete derivation of the equations. The model gives an accurate prediction of the pressure as a function of time when the NSI is fired into a 10 cm^3 volume. The prediction for the pin puller case has the right maximum pressure and final pin velocity; the times for the maximum pressure and completion of the stroke are also reasonably accurate. Because the propellant burns rapidly, the final results are insensitive to the values of some empirical parameters for the burn rate. The sensitivity results show that heat must be transferred from the condensed particles to the gas.

I. Other discussions.

Mr. Bement presented a chronological cost of the NSI (Attachment 20) and compared it with the costs of the explosive transfer lines. The concern was that the NSI, being procured by a build-to-print specification, did not allow manufacturers' creativity in reducing component costs. The belief was expressed that the difference was a result of not having a performance specification but using a build-to-print specification. Mr. Wittschen noted that the original price of a NSI was $35. The price increased later when the initial fixed-price contracts expired and again when there was a single qualified supplier. JSC has changed the NSI specification to incorporate some process improvements and is now qualifying a third source. Mr. Schulze suggested a more detailed discussion of NSI history as a topic for a future meeting.

IV. FUTURE MEETINGS

The Committee desires to stay together regardless of the Code Q funding situation. The Committee agreed to hold the next meeting at the Marshall Space Flight Center in October 1993. Mr. Harlan invited the Committee to meet at Sandia National Laboratory after the second Workshop planned for February 1994. A winter 1994 Steering Committee meeting should be planned, too, concurrent with the Workshop. There was great concern expressed about the ability of members to use travel funds to attend meetings, the problem being worse at some locations than others. The preference expressed was that early fiscal year travel is more likely to be approved. Also, the Workshop meetings and Steering Committee meetings should be held during the same week. Telecons were also welcomed.

V. ACTION ITEM SUMMARY

Action items from the Seventh meeting are:

1. Identify potential members for the Steering Committee at NASA Goddard Space Flight Center. (All, T. Seeholzer/Mar. 15, 1993)
2. Provide a list of publications for distribution to the Steering Committee. (J. Harlan/Mar. 15, 1993) [Refer to #8]
3. Review the discussion draft of the Pyrotechnic Specification and provide comments to JSC. (All/Mar. 15, 1993)
4. Distribute the quarterly reports on pyrotechnic modeling. (HQ/Mar. 15, 1993)
5. Coordinate transfer of separation system modeling project. (JPL, MSFC, Sandia/Mar. 15, 1993)
6. Send latest pyrotechnic related Military Standards to NASA Headquarters. (Aerospace/Mar. 15, 1993)
7. Ask manufacturers for information on the gas generating material for use in computer modeling. (LaRC/Mar. 15, 1993)
8. Provide input for the pyrotechnic data base, including a list of suggested publications, to LeRC. (All/Mar. 31, 1993)
9. Invite steering Committee members to the kickoff meeting for the contract with Ensign-Bickford for the Laser Safe and Arm system. (HQ/Jan. 15, 1993)
10. Provide a feedback on whether we should incorporate the specification information into the manual. (All/Mar. 31, 1993)

11. Suggest how the Committee can best make management/flight projects staff aware of its presence and talent. (All/Mar. 15, 1993)
12. The Committee was requested to provide topics for the next Workshop. Send suggestions to W. St. Cyr. (All/Apr. 15, 1993)
13. Invite Naval Surface Warfare Center, Indian Head, to join Committee. (HQ/Mar. 15, 1993)

All action item responses, unless otherwise noted, should be submitted to Mr. Norman Schulze, Code QE, NASA Headquarters, Washington DC 20546. He will distribute responses to the Committee members. When coordinated action is required, the underlined Center is responsible for making the response to Headquarters for the action item.

LIST OF ATTACHMENTS

Seventh NASA/DoD/DoE Aerospace Pyrotechnic Steering Committee

NASA Langley Research Center

December 8-10, 1992

1. Meeting Attendance List
2. Pyrotechnic Manufacturing Safety and AIAA Ordnance Working Group Information
3. International Pyrotechnic Society
4. Agenda
5. Committee Charter
6. Steering Committee Meeting, Introduction
7. NASA Technology Transfer Award for Excellence (NTTAE)
8. Summary of JPL Activities
9. MESUR Pathfinder Pyrotechnic Subsystems
10. NRL Introduction
11. PAS Program Introduction
12. Letters of Support

    Project 1.3 - Pyrotechnic Standard, Discussion Draft (provided in meeting)
13. Project 1.4 - PAS Database and Catalog
14. Project 1.7 - Pyrotechnic Manual
15. Project 2.1 - NASA Standard Gas Generator
16. Project 2.2.1 - Linear Separation System (Modeling of Galileo System)
17. Projects 2.4 and 2.5.1, Laser Safe and Arm/ Laser Initiated Detonator Evaluation
18. Project 3.6.1 - Service Life Extension
19. Project 4.2 - Modeling for the NSI Driven Pin Puller
20. Cost Comparison Chart for the NSI

Attachment 1

MEETING ATTENDANCE LIST

Seventh NASA/DoD/DoE Aerospace Pyrotechnic Steering Committee

NASA Langley Research Center

December 8-10, 1992

Name	Affiliation	Telephone
Norm Schulze	NASA HQS	(202) 358-0537
Anthony Agajanian	NASA JPL	(818) 354-9339
Barry C. Wittschen	NASA JSC	(713) 483-9042
Larry Rayburn	NASA KSC	(407) 861-3652
Larry Bement	NASA LaRC	(804) 864-7084
Tom Seeholzer	NASA LeRC	(216) 433-2523
Robert Stubbs	NASA LeRC	(216) 433-6303
William St. Cyr	NASA SSC	(601) 688-1134
John Hickman	NASA GSFC (WFF)	(804) 824-2374
Jim Gageby	Aerospace Corp.	(310) 336-7227
Jere Harlan	Sandia Nat. Lab.	(505) 844-4401
Floyd Z. Smith	Analex Corp. (LeRC)	(216) 977-0201
Les J. Wynn	Lockheed Eng. (JSC)	(713) 333-7795
Joseph M. Powers	U. Notre Dame (LeRC)	(219) 239-5978
William C. Wells	Vitro Corp. (HQ)	(202) 646-6350

ATTACHMENT 2

PYROTECHNIC MANUFACTURING SAFETY

A 3-1/2 Day Seminar
January 25-28, 1993
Long Beach, MS

Purpose: The Explosives & Pyrotechnic Safety Institute will offer a seminar on Pyrotechnic Manufacturing Safety. This seminar will be offered for the first time in 1993. The seminar will [illegible] basic knowledge in the field of pyrotechnics. The seminar will discuss the new OSHA [illegible] requirements, basic and practical theory of energetic materials, current areas of research, active interest in ongoing manufacturing processes, with specific discussions on sensitivity, mixing technology, output performance, equipment, reduction of waste and waste disposal.

Who Should Attend: The seminar should be of interest to those persons engaged in development, design, manufacture, regulation, disposal, evaluation and use of energetic materials.

Location: The seminar will be held at the Paradise Resort Inn, Long Beach, MS, which is located halfway between New Orleans, LA and Mobile, Al on the beach of the Mississippi Gulf Coast. Enjoy 26 miles of beach front, balmy climate, exceptional food and good entertainment. Room rates are [illegible] day with separate registration required. Contact Rightway Travel Inc. 1-800 746-8555 to make reservations.

Transportation: Gulfport Mississippi has an airport that is serviced by Continental, [illegible] ASA, Northwest Airlink and American Eagle. Participants may also choose to fly into New Orleans, LA and have transportation provided to the Paradise Resort Inn by [illegible]. Travel arrangements and room reservations can be made by Rightway Travel 1-800 746-8555.

Fee: The fee for the 3-1/2 day seminar is $995.00. This one payment includes tuition, instruction, daily lunch, refreshment breaks, lecture notes, and certificate of attendance. The Paradise Resort Inn has access to the beach, excellent eating facilities, tennis court, swimming pool. Registration will be limited to 30 participants per seminar, and will be accepted in the order received. Qualified applicants may be substituted at any time. We will honor cancellations and refund fees provided we are notified by January 11, 1993. Cancellations after January 11, 1993 will result in a $100.00 cancellation fee.

Topics to be Discussed

OSHA 1910.119	Energetic Materials	[illegible]
Factors Affecting Performance	Hazards Analysis Techniques	Manufacturing [illegible]
Layout and Operations	Mixing Technology	Mixing Equipment
	Disposal	

Lecturers: Larry Mars is a senior research chemist and a recognized authority in the energetics [illegible]. He has published over 80 technical reports on explosives, propellants and pyrotechnics, and presented technical papers at various National and International seminars. Larry Mars is a member of the American Chemical Society, ADPA Explosive and Pyrotechnics Section, Society of Explosive Engineers, American Defense Preparedness Association, International Pyrotechnic Society, National Fire Protection Association, National Management Association. Fred McIntyre is a senior project engineer who has been active in testing and safety for over twenty years. He has presented technical papers on [illegible] propellants, pyrotechnics and dust explosions at various international seminars. He has [illegible] such as "The Preparation, Evaluation and Loading Pyrotechnic Mixtures," "Manufacturing [illegible] Technology" and "Advanced Pyrotechnics".

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The Explosives and Pyrotechnic Safety Institute (EPSI) is a highly qualified and experienced group of experts dedicated to safety within the explosive and pyrotechnic industries. The explosive and pyrotechnic industry are their only concern. They understand that when you have to reach someone about your problems that it is important and we can respond rapidly to save time and money.

Identification and Evaluation of Hazards in the explosive and pyrotechnic industry has become a requirement. OSHA 1910.119 regulations apply to all companies who process highly hazardous chemicals (i.e., highly toxic, flammable or explosive). The standard referred to as Process Safety Management specifies the employer shall perform a hazard analysis for identifying, evaluating, and controlling hazards involved in process using certain methodologies. The hazard analysis shall be performed by a team, with expertise in the particular operations.

The basic OSHA Requirement for effective Process Safety Management will involve the following areas:

- ***Employee Participation***
- ***Process Safety Information***
- ***Process Hazards Analysis***
- ***Operating Procedures***
- ***Safe Work Practices***
- ***Training***
- ***Contractors***
- ***Pre-startup Safety Review***
- ***Mechanical Integrity***
- ***Management of Change***
- ***Incident Investigation***
- ***Emergency Planning and Response***
- ***Compliance Audits***
- ***Trade Secrets***

The Explosives and Pyrotechnic Safety Institute can assist you in developing a Process Safety Management Plan which is tailored to your company's specific needs. Services can be used in the design, construction and operation. Procedures can be used for both existing and new plants.

Capabilities of the Explosives and Pyrotechnic Safety Institute include the following:

- ***Qualitative Hazard Analysis and Quantitative Risk Assessment for Explosives and Pyrotechnic Facilities***
- ***Data Base on Sensitivity and Output of Energetic Materials and Accidents and Incidents within the Energetic Material Field***
- ***Accident and Incident Investigation***
- ***Operating Procedures Evaluation and Development***
- ***Testing of Explosives and Pyrotechnics (Sensitivity and Output)***
- ***Hazard Classification (DOT/DOD)***
- ***Training Courses and Instruction. Courses include: Manufacturing Safety and Technology, Explosives and Pyrotechnics Safety, Energetic Materials and HAZCOM course.***
- ***Q/D Determinations***
- ***Independent audits for compliance with DOD and OSHA regulations***

Let EPSI help You solve problems by contacting one of our knowledgeable staff. Phone (601)798-1710

C. F. WEBSTER **4526 MAYSVILLE RD N.E.**
HUNTSVILLE, AL 35811 **25 AUGUST 1992**

Mr. Norm Schulze
NASA Headquarters
600 Independence Ave.
Washington, DC 20546

Dear Mr. Schultze:

As a member of the Space Shuttle contractor community, a researcher in advanced pyrotechnic systems, and a member of the AIAA Ordnance Working Group, I wanted to express my appreciation for what your Pyrotechnic Steering Committee did through the Workshop held this past June at Johnson Space Center.

As you may be aware from Art Rhea, the AIAA Ordnance Working Group is a rather new effort with goals which are, in many ways, complementary to those of your Pyrotechnic Steering Committee. I wanted to express my appreciation for the opportunity provided to use the Workshop as a forum to advance the goals of both organizations.

As Membership Coordinator for the AIAA Ordnance Working Group, I was concerned to note that we have representative members from various contractors, vendors, and government agencies, but we have only one NASA member, Larry Bement of Langley. I would like to encourage members of your Pyrotechnic Steering Committee to consider participation, or to encourage participation by appropriate fellow NASA employees. With that in mind, I have enclosed a copy of our membership application form for distribution as you may see fit. If you agree with the goal of a broad aerospace ordnance representation on this AIAA working group, I would appreciate any encouragement you may provide to potential NASA participants.

Yours,

C F Webster

C. F. Webster

AIAA TECHNICAL COMMITTEE (TC) NOMINEE FORM

Date__________ Nominee for TC on ADVANCED ORDNANCE TECH. COMMITTEE

Name (Mr\Ms\Dr\Prof) ______________________________

Title______________________________

Birthdate______________

Organization______________________________

Address______________________________

______________________________Zip__________

Telephone (______)____________Fax (______)____________

Home Address______________________________Apt.__________

______________________________Zip__________

Preferred mailing address: ( ) Business ( ) Home

College or Univ______________________________Year_______

Degree______________________________Major__________

Graduate degrees______________________________

Graduate Schools______________________________

Primary professional interest______________________________

____

Secondary professional interest______________________________

____

Positions held pertinent to above______________________________

____

____

____

Honors and/or awards______________________________

____

AIAA TECHNICAL COMMITTEE (TC) NOMINEE FORM - CONTINUED

AIAA membership grade & number____

If not a member, eligible for Associate Membership?____yes____no

AIAA offices held____

____

Membership in other societies, committees, boards, or AIAA Technical Committees____

____

Nomination submitted by____

Title____

Organization____

Address____

____Zip_______________

Telephone (______)____

Date________________________

TO: AIAA Advanced Ordnance Committee

As the nominee's supervisor, I concur that if ________________________ is selected as a member of the AIAA Advanced Ordnance Technical Committee, he/she will be supported by his/her organization to attend and participate in committee functions, including meetings and related activities.

Sincerely,

____
(Supervisor's signature)

____
(Supervisor's Printed Name)

____
(Supervisor's Title)

____
(Organization Name)

ATTACHMENT 3

THE INTERNATIONAL PYROTECHNICS SOCIETY, INC.

CONSTITUTION

NAME This Society is named "The International Pyrotechnics Society, Inc."

PURPOSE The purposes of this Society are:

1. To promote and facilitate the exchange of information concerning the art and science of pyrotechnics among all interested persons.

2. To create and maintain an information bank which can speed, or simplify, a member's search for information regarding a pyrotechnic material, composition, device, manufacturer or research study.

3. To sponsor or sanction meetings on pyrotechnics at such intervals and on such subjects as may be appropriate to further its first purpose above stated.

4. To encourage pyrotechnic research and education.

5. To establish standards of safety, performance and quality for pyrotechnic devices, manufacture, materials and research.

ORGANIZATION The Society will be composed of the following International, National and Local organizations:

1. The International Pyrotechnics Society, with officers and members from any or all of the participating countries.

2. National Departments, e.g."Canadian Department of The International Pyrotechnics Society" composed of the members who are resident in a country and officers elected by the national department members.

3. Local Divisions may be created if warranted by the numbers and activity of the members in a large section of the Department area, e.g., "The Alberta Division of the Canadian Department".

4. If warranted by the numbers and activity of the membership in a small part of a Department area, a chapter, e.g., "Calgary Chapter, Alberta Division, Canadian Department" may be formed.

MEMBERSHIP Membership is open to all persons who have and can show a bonafide interest in pyrotechnics as it is defined in the by-laws. Members will be categorized as: 1) Charter Member, 2) Regular Member, 3) Corporate Member (a. Sustaining, b. Supporting or c. Patron), 4) Life Member, 6) Honorary Member.

OFFICERS

International. The elected officers of the International Pyrotechnics Society shall be a President, two Vice-presidents, a Secretary, an Archivist, and a Treasurer. The offices of Secretary and Treasurer may be occupied by the same person, if elected by the members.

National. Elected officers of Departments, Divisions and Chapters of this Society will be a President, a Vice-President, a Secretary/Treasurer, and an Archivist.

TERMS OF OFFICE

International

1. All officers of the International Society will be elected by vote of the members to serve a term of two years.
2. The President and Vice-presidents may not serve more than two terms.
3. The Secretary and Treasurer may serve at the pleasure of the membership, for a maximum of ten years, in either or both offices.
4. The Archivist may serve at the pleasure of the membership for a maximum of twenty years.

National Departments, Divisions and Chapters

1. All officers of the National and Local societies will be elected by vote of the national and local members, respectively, to serve a term of one year.
2. The President and Vice-president may not serve more than two terms.
3. The Secretary-Treasure, may serve at the pleasure of the membership, for a maximum of six years. The Archivist may serve at the pleasure of the Membership for a maximum of ten years.

SUCCESSION

The President and Vice-president may not succeed themselves. If an office is vacated, succession will be determined by the ranking of candidates on the most recent regular ballot. If the ballot does not provide a successor, the other officers will select a successor to serve until the next regular election. This individual may continue in this office for the next term if elected by a regular ballot. He may serve two full terms if elected by regular ballot of the membership.

INSTALLATION

International officers will assume their duties at the General Business Meeting immediately following the announcement of their election. It is intended that this meeting occur during the first days of a biennial meeting for the presentation of scientific papers, which meeting lasts for three or more days and is international in scope.

National and local officers will be installed at the next regular meeting following their election.

FINANCES

The financial operations of the Society shall be subject to the following:

1. The Fiscal year shall begin at 12:01 AM, July first and terminate at midnight, June thirtieth.

2. Disbursements may be made only by two-signature check.

3. The President, Vice Presidents, Secretary and Treasurer will be authorized to sign disbursement checks and will be bonded as determined by the Governing Board.

4. Income is to consist of annual dues, gifts or contributions, meeting and registration fees, revenue from Society publications and service fees.

5. All income is to be deposited in a federally insured savings account, or the national equivalent, from which funds may be withdrawn by two signatures for deposit to a checking account in a federally insured savings institution or bank, or the national equivalent. The balance in the checking account may not exceed ordinary expenses for a two month interval by more than ten percent. Checks drawn against this account require two signatures, as authorized in the By-laws.

6. Officers will serve without remuneration. They will be reimbursed for essential and reasonable expenses incurred in the performance of their duties. Expenses in excess of the limit set in the Bylaws must be approved by the Finance Committee before they are incurred.

BUSINESS MEETINGS

International. One General Meeting will be held at least every two years, primarily for the presentation of current work in pyrotechnic research and development. Note: This will, in effect, be held concurrently with the International Pyrotechnic Seminars begun in 1968. A General Business Meeting of past, present, and newly elected officers will be held at the biennial General Meeting. Results of elections, and any other actions by the membership and officers during the preceding biennium, will be presented at the opening session of the General Meeting.

National. At least one National Departmental, and one Divisional business meeting, will be held every year for the conduct of essential business and the installation of officers. These meetings may not be scheduled in a manner that conflicts with attendance at the International General Meeting. Local chapter meetings shall be held at the pleasure of their members.

VOTING RIGHTS

All members in good standing may cast one vote in all general elections and meetings, unless voting rights are restricted by the By-laws.

ELECTIONS

Election of officers and changes in the By-laws will be decided by a simple majority of the ballots received from the active* membership.

PUBLICATIONS

The following items will govern publications:

1. The International Society may publish papers presented at the biennial General Meeting, and such other publications as the International Society may approve by a 51% affirmative vote of the active membership.

2. The cost of publications shall be defrayed by revenue derived from their sale; the revenue may be supplemented by general revenues of the International Society when approved by a 51% affirmative vote of the active International Membership. Percentage is to be computed on the ballots received within six weeks.

3. The International Archivist will be responsible for the action necessary to ensure editing, publishing, and distribution of publications.

4. The official journal for the International Pyrotechnics Society is "Propellants, Explosives and Pyrotechnics" published by VCH.

CONSTITUTIONAL AMENDMENTS

Amendments to the Constitution may be presented by any member to the officers. A three-fourths affirmative vote by the officers is required to present the suggested change to the membership for their action by a referendum. A two thirds affirmative response to the referendum is required for the adoption of the proposed change. The referendum will be held by a simultaneous mailing of ballots to the active membership. Six weeks from the date of mailing, the returned ballots will be tallied and the referendum closed. Results will be announced by a mailing to all active members.

*See Bylaws, Article II, Sec. B, Item 5. "Active" means "in good standing".

PREFACE

This is the Eighteenth International Pyrotechnics Seminar (IPS) of this series, and the thirteenth to be held in the United States. The Tenth IPS was held in Germany, the Twelfth IPS in France, the Fourteenth IPS in the United Kingdom, the Sixteenth IPS in Sweden, and the Seventeenth IPS in the People's Republic of China. The Nineteenth IPS will be held in New Zealand in February 1994.

The International Pyrotechnics Seminars, which commenced with the First in Estes Park, Colorado, in 1968, are today accepted as the major international forum for pyrotechnics, which is defined by international context to include explosives and propellants, as well as most topics involving the energetics of chemical reactions. These seminars provide the forum for the field of energetic materials that are considered outside the scope of other major symposia, such as the International Symposium on Combustion and the International Symposium on Detonation. It is hoped that as all of these symposia continue to evolve and grow that they strive to complement each other and provide a forum for scientists, engineers, and others who wish to share their knowledge with colleagues throughout all countries of the world in their quest to make our world better, safer, healthier, and greater both economically and ecologically.

I have had the privilege now of serving as chairman for the U.S.A. Seminars since 1980, and as the internationality of each succeeding seminar grew, I, as well as many of you, had concern whether they could be sustained, especially when these seminars were held every year. I no longer have this concern, as I believe that the success of these seminars is now well established, even as economic and political problems around the world abound.

This Proceedings contains over 85 papers, of which more than half are from countries other than the United States. This represents an excellent effort from the international pyrotechnics community, with contributions from over a dozen countries. Unfortunately, a number of papers to be presented at this Seminar are not included in this Proceedings because they were not received in time. The authors of some of these papers will provide copies at the Seminar, and others may be published at a later date in the journal Propellants, Explosives, Pyrotechnics. On the other hand, some papers published in this Proceedings will not be presented because the author(s) are unable to attend. We also have an excellent Poster Session scheduled, with about 15 papers. Attendance at this Seminar is anticipated from over twenty countries.

I wish to thank the members of the Steering Committee, the Officers of the International Pyrotechnics Society, the Session Chairmen for the Seminar, the authors of all contributed papers, and lastly but not the least, the participants of this Seminar for its success and its influence on the continued success and growth of all future International Pyrotechnics Seminars.

On behalf of the Steering Committee for this Seminar and the International Pyrotechnics Society, I wish all participants a most enjoyable and informative experience. Please contact me or any Member of the Steering Committee or any Officer of the International Pyrotechnics Society for information, comments, suggestions, or any other matter that you might wish to discuss. It is our sincere intention to improve where we can, and to make future seminars even more enjoyable and informative for you, the participants, especially when you travel great distances at considerable cost in order to attend and participate. My best regards to all of you, and enjoy your Seminar!

Allen J. Tulis, Chairman
International Pyrotechnics Seminars U.S.A.

JULY, 1992

IIT Research Institute

CONTENTS

PRECEDING PAGE BLANK NOT FILMED

Paper | Page

*Note: The authors of these papers and/or the respective page numbers are not tabulated in the Author Index.

ATTACHMENT 4

Agenda

Seventh NASA/DOD/DOE Pyrotechnics Steering Committee Meeting

Langley Research Center

Building 1209, room 178

December 8-10, 1992

Tuesday, December 8, 1992

8:15	Introductory comments –Minutes review and action item review	Norm Schulze
8:30	Welcome	Bob Swain
9:00	Open forum discussion by centers: Program status, new developments, issues, failures, problems, etc. 5 minute discussion per member on key points to be made, including new information and projects underway	All members
	AF, Navy, and DOE comments	Jim Gageby Jerry Laib Jere Harlan
10:00	BREAK	
10:15	NRL activities	Bill Purdy
	PAS Program Review	
10:45	1.3 Pyrotechnic Specification, including discussion on it being a specific versus general type of document	Barry Wittschen
12:00	LUNCH	
1:00	1.4 Data Base	Tom Seeholzer
2:00	1.7 NASA PAS Manual	Larry Bement
3:00	BREAK	
3:15	2.1 NSGG	Larry Bement
4:15	3.6.1 Service Life Extension	Larry Bement
4:30	Adjourn	

Wednesday, December 9, 1992

	Laser Initiated Ordnance topics:	
8:00	Safe and Arm for Pegasus and JSC activities	Barry Wittschen
8:45	NRL pyrotechnic activities	Bill Purdy
9:30	Laser Initiator Flight Demonstration	Bill Purdy
10:00	Spartan flight demonstration	Don Carson
10:30	BREAK	

10:45	2.2.1 Linear Separation System	Tony Agajanian/ Larry Bement
11:15	4.2.1 Pyrotechnic Model Development	Bob Stubbs
12:00	LUNCH	

<u>Steering Committee Discussions</u>

1:00	Discussion of Charter and functions of Committee	All members
3:00	BREAK	
3:15	Potential cooperatives ventures with DOE	Jere Harlan
3:45	Potential cooperative ventures with DOD	Jim Gageby Jerry Laib
4:30	Adjourn	

Thursday, December 10, 1992

8:00	Revamping of PAS Program Plan	All members
11:00	Planning for future activities	All members
12:00	Adjourn	

ATTACHMENT 5

DRAFT

REVISION 4

NASA/DOD/DOE Aerospace Pyrotechnic Systems Steering Committee Charter

April 8, 1992

Goals:

To provide an effective, organized forum for identifying critical aerospace pyrotechnic systems technology needs and issues, and the technology developments required to improve safety and mission quality. To facilitate communications and coordination among the aerospace pyrotechnic systems technical community.

Functions:

The Committee is organized to: identify opportunities for technology applications that improve safety and mission quality, provide technical advice to management on aerospace pyrotechnic issues, serve as a readily available resource for reviews of development and applications programs, and disseminate technology developments.

Objectives:

The Committee shall:

1. Provide a forum for the NASA/DOD/DOE aerospace pyrotechnic systems community to convene for review of: technology requirements and developments, design/test/operational experiences, pyrotechnic hardware problems and solutions, near term system applications, status of current pyrotechnic programs/applications, and advanced development program plans.

2. Serve in an advisory capacity to the Program Manager of the NASA Aerospace Pyrotechnically Actuated Systems Program. Accomplish ad hoc reviews and perform assigned actions within available resources for the NASA Aerospace Pyrotechnically Actuated Systems Program.

3. Accomplish ad hoc reviews and perform assigned actions within available resources that assist flight and ground programs.

4. Provide a planning and advocacy function for the generation and management of new pyrotechnic systems and development programs which will advance the technology.

5. Foster inter-center/agency cooperation and understanding of developments concerning pyrotechnic devices, minimize duplication of efforts, identify problems which might have mutual impact, and discuss new developments which are of mutual interest and

operational advantage to the pyrotechnic community.

6. Review matters relating to policy and practices in the pyrotechnic discipline across NASA field installations with the objective of achieving consistency. Coordinate matters relating to policy, specifications, standards, and practices in the pyrotechnic discipline across appropriate government organizations.

7. Coordinate technical efforts within the NASA field installations and between NASA, DOD, and DOE.

8. Serve in an advisory role for pyrotechnic discipline training, education, and facilities. This role includes activities that maintain a pyrotechnic data base to help assure that information is retained as programs and personnel change and that a well-staffed hands-on expertise exists.

9. Be cognizant of and address pyrotechnic-related environmental, health, and safety issues.

Scope:

Activities which fall within the consideration of this Committee include: the design, development, test, operations (including disposal), and evaluation of pyrotechnic and explosive systems, initiators, explosive charges, safe/arm devices, etc. "Systems" include the means by which pyrotechnic devices may be initiated as well as integration of components associated with the pyrotechnic actuated mechanism and their integration into the vehicle of application.

Membership:

The membership is open to government organizations having a need for involvement in the Committee's activities in aerospace pyrotechnically actuated systems. The meetings will be chaired by a NASA Code QE representative.

Meeting frequency:

The Chair will call meetings as necessary. It is anticipated that this will nominally be twice annually.

Meeting Location:

The meetings will be held at governmental installations or other appropriate locations as deemed necessary by the Committee in the conduct of its business.

Approved: ______________________________ Date: ______________

Dr. Daniel R. Mulville
Director, Technical Standards Division

Approved: ______________________________ Date: ______________

Department of Defense

Approved: ______________________________ Date: ______________

Mr. Heinz Schmitt
Vice President, Engineering Design and Development
Sandia National Laboratory

ATTACHMENT 6

OSMQ

Seventh NASA-DOD-DOE Pyrotechnic Systems Steering Committee

Norman R. Schulze

Langley Research Center

December 8-10, 1992

Introduction

OSMQ

Topics

- General
- Meeting Objectives
- Status
- Issues
- New SBIR Solicitations Submittals
- Support for Program
- Charter
- Roster
- Minutes review and action item review

General topics

- Workshop Proceedings published
- Pyrotechnic Manufacturing Safety seminar; Jan. 25-28, 1993, Long Beach, CA
- AIAA Ordnance Working Group: Invitation to join.
- New participants

– NRL:	Mark Frata	Phone: 202-574-7330	FAX: 202-574-7333
–	Bill Purdy	Phone: 202-767-0529	FAX: 202-767-6429
– KSC:	Larry Rayburn	Phone: 407-861-3652	

- NASA Technology Transfer Award for Excellence
- Small Business Innovative Research (SBIR) Programs

Agenda

Tuesday, December 8, 1992

8:15	Introductory comments –Minutes review and action item review	Norm Schulze
8:30	Welcome	Bob Swain
9:00	Open forum discussion by centers: Program status, new developments, issues, failures, problems, etc. 5 minute discussion per member on key points to be made, including new information and projects underway	All members
	AF, Navy, and DOE comments	Jim Gageby Jerry Laib Jere Harlan
10:00	BREAK	
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Tuesday, December 8, 1992

OSMQ

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Agenda

Thursday, December 10, 1992

OSMQ

8:00	Revamping of PAS Program Plan	All members
11:00	Planning for future activities	All members
12:00	Adjourn	

Meeting Objectives

OSMQ

- Review program
- Determine the function/operation of the Steering Committee in view of the current changes.
- Where does the Committee head from here?

Status

OSMQ

- Blue team-Red team activities
- Organizational changes:
  - Fred Gregory: Associate Administrator for Safety and Mission Quality (same)
  - Chuck Mertz: Acting Deputy Associate Administrator for Safety and Mission Quality (replaces Charles Pellerin)
- Pyrotechnic program being phased out. Only model remains after FY93. All concludes after FY94.
- Code R: research office in NASA split into Aeronautics (R) and Advanced Concepts and Technology (C)
  - R/Acting Associate Administrator, Cecil Rosen
  - C/Acting Associate Administrator: Gregory Reck

Issues

OSMQ

- Funding for non NASA committee to participate in meetings
- Working agreements

New SBIR Solicitations Submitted

OSMQ

- Contact: John Glaab, Code C, 202-488-2931 Headquarters or N. Schulze 202-358-0537
  - Conduct research to develop the means to reduce the short duration, high frequency, mechanical shock associated with hot bridge wire initiators.
  - Determine new design approaches that will significantly reduce or eliminate the potential for generating transient electrical pulses associated with firing hot bridge wire initiated pyrotechnic devices which can cause undesirable effects on delicate electronic circuits or components.
  - Develop approaches that will use new technologies that will effectively train to provide for enhanced quality.
  - Develop innovative approaches for a spacecraft separation system that is non-contaminating (no debris), has low shock, provides for a high functional margin of safety, is low cost, and is highly reliable.

SBIR Solicitations (Continued)

OSMQ

- Develop novel knowledge base systems that will analyze hardware requirements and compare results to create optimal program requirements. Inputs to be considered are: requirements, plans, procedures, testing requirements and failures, flight failures, manpower, costs, etc.
- Conceive and develop a new method to make the NASA technical/management community more aware of proper pyrotechnic techniques, approaches, and practices that will assure mission success.
- Conduct research on innovative methods and on innovative technologies that will provide significant gains in the quality of space and aeronautical hardware. In this endeavor we seek new approaches concerning methodologies as well as specific hardware quality enhancements.
- Conduct research on innovative methods and on innovative technologies that will provide significant gains in the safety of space and aeronautical hardware and operations. In this endeavor we seek new approaches concerning methodologies as well as specific safety enhancements.

SBIR Solicitations (Continued)

OSMQ

- Conduct research on innovative methods and on innovative technologies that will provide significant gains in the reliability of space and aeronautical hardware. In this endeavor we seek new approaches concerning methodologies as well as specific hardware reliability enhancements.
- Conduct research on innovative methods and on innovative technologies that will provide support or will enhance - relative to proposed techniques - the safety, reliability, and quality of future space and aeronautical missions. In this endeavor we seek new approaches concerning methodologies as well as specific hardware or operational approaches.
- Develop novel knowledge base systems that will analyze hardware requirements and compare results to create optimal program requirements. Inputs to be considered are: requirements, plans, procedures, testing requirements and failures, flight failures, manpower, costs, etc.
- Conceive and develop a new method to make the NASA technical/management community more aware of proper pyrotechnic techniques, approaches, and practices that will assure mission success.

SBIR Solicitations (Continued)

OSMQ

- Conduct research on innovative methods and on innovative technologies that will provide significant gains in the quality of space and aeronautical hardware. In this endeavor we seek new approaches concerning methodologies as well as specific hardware quality enhancements.
- Conduct research on innovative methods and on innovative technologies that will provide significant gains in the safety of space and aeronautical hardware and operations. In this endeavor we seek new approaches concerning methodologies as well as specific safety enhancements.
- Conduct research on innovative methods and on innovative technologies that will provide significant gains in the reliability of space and aeronautical hardware. In this endeavor we seek new approaches concerning methodologies as well as specific hardware reliability enhancements.
- Conduct research on innovative methods and on innovative technologies that will provide support or will enhance - relative to proposed techniques - the safety, reliability, and quality of future space and aeronautical missions. In this endeavor we seek new approaches concerning methodologies as well as specific hardware or operational approaches.

Support for Program

OSMQ

- Excellent support being given to program
  - Ensign Bickford, President & CEO: Hugh G. Caldwell, September 2, 1992. LetterLetter to Goldin
  - Explosive Technology, President, G. Ben Huber, October 26, 1992. Letter to Frederick Gregory
  - Hi Shear, President, Thomas R. Mooney, November 20, 1992. Letter to Frederick Gregory
  - Mound, Unknown – response to Congressman Hall, August 5, 1992, Letter to Congressman Hall.
  - AIAA Ordnance Working Group: Membership Coordinator for the AIAA Ordnance Working Group and Space Shuttle contractor Community, C. F. Webster, Aug. 25, 1992. Letter to Norman Schulze on the value of the Workshop.

Charter

OSMQ

- Approved by committee members
- Approved by Dr. Mulville
- Revise to reflect changes?

Roster

OSMQ

- Present and discuss format

Minutes Review and Action Item Review

OSMQ

- Transmitted out as draft
- Comments solicited
- No changes received - limited response

ATTACHMENT 7

NASA
National Aeronautics and
Space Administration
Washington, D.C.
20546

NOV 25 1992

Reply to Attn of: CU

TO: NASA Field Center Technology Utilization Officers
THRU: Director, Technology Transfer Division

FROM: Chairman, NASA Technology Transfer Award for Excellence (NTTAE)

SUBJECT: Call for Submissions from NASA Field Centers for Candidacy for the NASA Technology Transfer Award for Excellence (NTTAE)

As you are aware, over the past months, the NASA Headquarters Technology Transfer Office has been working to establish a NASA Technology Transfer Award for Excellence (NTTAE). The NTTAE Executive Committee has been working steadfastly to accomplish this effort. We are now prepared to issue this "Call for Submissions."

To reiterate our objective for this worthwhile event, the purpose of the NTTAE is to honor a NASA Field Center for its outstanding contributions to effectively transferring NASA developed technology to the private sector and non-aerospace community. Determination of the award recipient will be based on your activities and accomplishments achieved within the previous calendar year. This assessment includes effective performance as it relates to your Centers innovative approaches and ability to obtain results from successful management and technology transfers processes.

As the committee continues to prepare for a 1993 award, we would appreciate your participation and cooperation in submitting a quality proposal in the time designated herein. Please adhere to these guidelines as time is of essence and we have very little flexibility.

For your information, preparation guidelines are enclosed.

If you have any questions, please contact me at (202) 358-0704.

Janelle B. Turner

Janelle B. Turner

Enclosures

PROPOSAL GUIDELINES

Attachment A

Proposal Requirements

The proposal should provide sufficient, explicit information to be evaluated in terms of your Center's technology transfer activities as it relates to the four criteria specified in Attachment B. Specifically, these factors and their assigned weights are:

I. Management Processes (15%)
II. Transfer Processes (25%)
III. Accomplished Transfers (45%)
IV. External Measures (15%)

The proposal should be self-contained and written with thoroughness and accuracy. Additionally, the 'author' should ensure inclusion of all essential information requested and needed for evaluation by the review committee. Please provide metrics where applicable to quantify achievements.

All information submitted will be used for evaluation purposes only and protected from unauthorized use or disclosure.

General Content Requirements

Submissions must not exceed ten (10) pages. Appendices and/or attachments are not permitted. Each page should be appropriately numbered at the center bottom.

Proposal Format

Proposals should be submitted in the following format:

Cover Page	-	Include name of Field Center
Section 1.0	-	Management Processes
1.1	-	Management Support
1.2	-	Reporting
Section 2.0	-	Transfer Processes
2.2	-	Documentation/Information Process
2.3	-	Outreach Initiatives
Section 3.0	-	Accomplished Transfers
3.1	-	Center Services
3.2	-	Projects and Agreements
3.3	-	Public/Private Applications
Section 4.0	-	External Measures
4.1	-	Awards and Recognition
4.2	-	Customer Viewpoint

Proposal Forwarding Address

Submissions should be addressed to:

NASA
Office of Advanced Concepts and Technology
Code CU
Washington, DC 20546
ATTN: Ms. Janelle Turner

or

if sent overnight express:

NASA
300 E Street, SW
Rm. 4X40
Washington, DC 20546
ATTN: Ms. Janelle Turner

All proposals must bear the signature of the Center Director and the Technology Transfer Officer.

Deadline for Submissions

All proposals must be submitted no later than 5:00pm (EST) December 31, 1992.

Inquiries

Questions pertaining to this call for submissions should be directed to Janelle Turner at (202) 358-0704.

Attachment B

NASA TECHNOLOGY TRANSFER AWARD FOR EXCELLENCE (NTTAE)

Selection Criteria

Determination of the award recipient (Field Center) will be based on overall Center performance in promotion, management, and achievement of technology transfer (TT) to the non-aerospace community and the private sector during the previous calendar year. Performance assessment will be based on a single Center submitted document describing relevant activities that will be evaluated according to the following factors and weights. Where appropriate, determining and citing evidence of value or success to industry (e.g., changes in technologies, methods, approaches or tools used; realized or projected economic or competitive impact) is encouraged.

I. MANAGEMENT PROCESSES (15%)

1. (10%)-Management Support: Center for senior management support as evidenced by: a) new actions taken to promote and encourage sustained contributions of the Center personnel and programs in technology transfer; b) implementation of previous actions to promote technology transfer, including internal Center recognition of its employees; c) use of Center resources to support TT activities; and d) efforts to impart TT responsibility to Center staff (such as employee orientation, training and performance evaluation).

2. (5%)-Reporting: Completeness and timeliness of reports concerning technology transfer activities, including: a) Center TU Annual Report; b) Annual Research and Technology Reports; c) project reports; and, d) quality of program reviews.

II. TRANSFER PROCESSES (25%)

1. (5%)-Documentation/Information Process: Quantitative and qualitative improvements of performance in : a) new technology information acquisition; b) publication and dissemination (e.g., Tech Briefs); and, c) software submittals to COSMIC.

2. (5%)-Outreach Initiatives: Center involvement in: a) national and regional outreach activities and government entities and industrial groups; b) technical community TT events such as industry workshops and seminars and annual conferences and expositions, and c) use of local and regional media to promote technology transfer.

3. (10%)-<u>User-Focused Processes:</u> Implementation or improvement of technology processes that a) promote specific industry (user) efforts in identifying, adapting, and incorporating transferred technologies; b) identify how NASA's technology is used in industry (customer measures, needs, and satisfactiion) and, c) incorporate industry feedback into NASA programs.

4. (5%)-<u>Barrier Removal:</u> Center efforts in: a) identifying barriers to technology transfer and b) creating and implementing methods to overcome them.

III. ACCOMPLISHED TRANSFERS (45%)

1. (15%)-<u>Center Services:</u> Center support to industry such as a) technology guidance through review, evaluation and interaction with industry with respect to independent research and development (IRAD) projects and plans; b) industry utilization of Center tools and facilities (computers, test-beds, space simulation facilities, wind tunnels); and c) handling of industry requests for problem solving and technical support.

2. (15%)-<u>Projects and Agreements:</u> Establishment and progress of joint efforts with industry for technology transfer purposes, such as: a) joint engineering projects; and, b) number and type of Space Act or Aeronautics Agreements.

3. (15%)-<u>Public/Private Applications:</u> Technology transfer through: a) industry licenses applied for and granted, based on NASA technology; b) NASA patents granted; c) royalties received, d) documented, attributable use of specific technologies by industry.

IV. EXTERNAL MEASURES (15%)

1. (5%)-<u>Awards and Recognition:</u> Center recognition by outside organizations (e.g., RD-100, US Space Foundation, Federal Laboratory Consortium, engineering/ professional organizations, aeronautics industry).

2. (10%)-<u>Customer Viewpoint:</u> Center method and activities to: a) obtain feedback from industry on the value of NASA Technology Transfer to them (e.g., how they measure success of technology transfer or use it to guide their programs) and, b) determine and incorporate customer needs into NASA plans (e.g., Customer-NASA interactive planning of NASA technology programs).

ATTACHMENT 8

JPL

JET PROPULSION LABORATORY

SUMMARY OF ACTIVITIES

By

ANTHONY AGAJANIAN

December 8, 1992

JPL

NEW PROJECTS

MESUR

MARS ENVIRONMENTAL SURVEY

OBJECTIVES

TO PERFORM GLOBAL (NOT LOCAL) SCIENCE ON THE SURFACE OF MARS UTILIZING MINIATURE ROBOTIC ROVERS

- METEOROLOGY
- SEISMOLOGY
- GEOLOGY (ROCKS & SOIL)

MISSION PROFILE

PATHFINDER - 1996

NETWORK - 1999 TO 2001

AMA 12/8/92

JPL

NEW PROJECTS

PATHFINDER

SEND 1 TO 2 TEST LANDERS TO

- PROVE ENTRY, DECENT AND LANDER TECHNOLOGY
- PERFORM ROVER MOBILITY EXPERIMENTS
- PERFORM SIMPLE SCIENCE

• 150 MILLION (EXCLUDING LAUNCH VEHICLE)

• 450 Kg TOTAL MASS (800 Kg LIMIT)

JPL

NEW PROJECTS

NETWORK

SEND 16+ LANDERS TO MULTIPLE PLANET SITES

- POSSIBLY UTILIZING MICRO ROVERS

- 1 BILLION (EXCLUDING LAUNCH VEHICLE)
- 200 Kg TOTAL MASS per LANDER

JPL

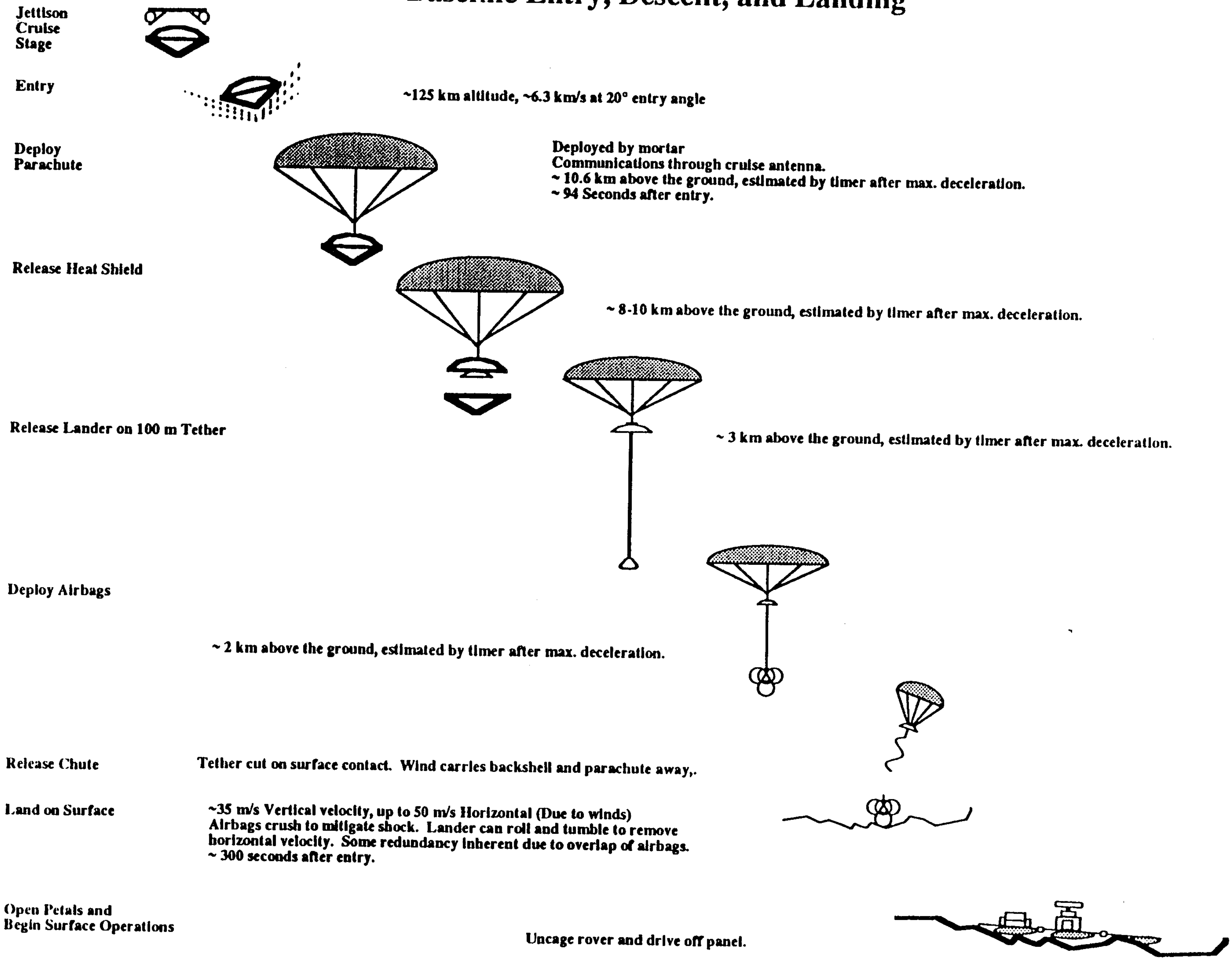
NEW PROJECTS

PYROTECHNIC REQUIREMENTS

12 PYROTECHNIC EVENTS INCLUDING

- LAUNCH RESTRAINT & RELEASE
- PARACHUTE MORTAR
- ATTENUATION BAG INFLATION
- LINE CUTTERS

Baseline Entry, Descent, and Landing



ATTACHMENT 9

MESUR PATHFINDER PYROTECHNIC SUBSYSTEMS

As shown in figure 1, Pathfinder will require the following pyrotechnic subsystems: 1) Cruise Stage-to-capsule release, 2) capsule despin, 3) aeroshell release from back cover, 4) parachute jettison, and 5) lander release from the back cover. This text will describe each of the subsystems in the order of their occurrence.

1. Cruise Stage-to-capsule release - The Pathfinder capsule will be released at three points by a typical separation nut, shown in figure 2. Firing either NASA Standard Initiator (NSI)-initiated gas-generating cartridge will provide sufficient energy to release and jettison the attachment bolt. The three-section nut (thread segments) is held in place by the cylinder of the piston. Release is accomplished by the cartridge's output gas driving the piston from right to left to allow the thread segments to be forced into a receiving cavity. The driving force for this action is obtained from the separator's angular face acting against the thread segments. The bolt is ejected out of the body of the nut by the ejector, a piston contained within the separator. All products of combustion are retained within the body of the nut. Bolt ejection is necessary to assure no interference at the separation plane. The jettisoned bolt is captured by a bolt catcher shown in figure 5 to assure that the interface remains uninhibited.

   These separation nuts have been flown on a wide variety of aerospace missions, including two separation planes on the Viking Lander. Two cartridges, each fired by an independent firing system for each nut, provides redundancy. For rigid, single-point attachments, separation nuts have proven to be simpler and more reliable than other devices, such as separation bolts.

2. Capsule despin - The capsule will be despun through the release of two tethered weights. The tethering cables are wrapped around the capsule and are released by pin pullers. Details of this design are provided in a separate document.

   Qualified pin pullers, residual from the HALOE Instrument and Viking cartridges, residual from Viking are available for this mission.

3. Aeroshell release - The aeroshell will be released by an explosive severance of the back cover, as shown in figures 4 and 5. Two 180-degree lengths of flexible linear shaped charge (FLSC) will be installed against the skin of the back cover to achieve complete severance. View B-B in figure 4 details the interfaces in the manifold. The FLSC ends, each with a cylindrical booster tip are inserted

into the manifold to be initiated by an NSI detonator. On functioning, the explosive products are contained within the shield, as shown in figure 5. On initiation of the FLSC, the explosive pressure wave forces the flexible foam into the interface between the shield and the skin to minimize contamination of the payload during release.

This approach to explosive severance has been widely used in aerospace applications for staging in the Saturn V and Delta launch vehicles. The flexible foam sealing technique was qualified for an in-flight escape opening on an LaRC aircraft. The advantages of this approach for this application are its reliability, simplicity, and low weight. A continuous separation joint is more reliable than is a multi-point attachment for which each attachment must be initiated separately. The explosive charge can be located at virtually any desired location and can sever primary structure with no further accommodations than to hold it in place. Another major advantage in this release approach is that the aeroshell structural design can be simplified through the use of a stiffened ring, rather than a multiple, single-point, less-reliable release plane. This approach weighs 10 percent of a totally confined, continuous separation joint called Super*Zip.

4. Parachute jettison - The mortar-driven parachute jettison to accomplish parachute deployment is described in a separate document.

5. Payload release - The payload will be released from the back cover at three points with the separation nuts described in item 1 above.

All pyrotechnic devices have been selected on past history, particularly qualification status, and performance. The NASA Standard Initiator (NSI) will be used at all electrical to pyrotechnic interfaces. All explosive materials have been selected for thermal/vacuum stability.

The technical risk for these systems is relatively low. The separation nut will require a demonstration of functional margin to assure its success. The cartridge energy source, currently under development at LaRC, will have an adequate output. An engineering effort will be required to demonstrate system-level performance, such as noninterference and separation forces and dynamics. The aeroshell release will require the most technology development, particularly in providing containment for explosive products and minimizing system weight. No new facilities will be required for these developments.

These pyrotechnic approaches would be directly applicable to the Network Probes.

Pathfinder Pyrotechnic Subsystems

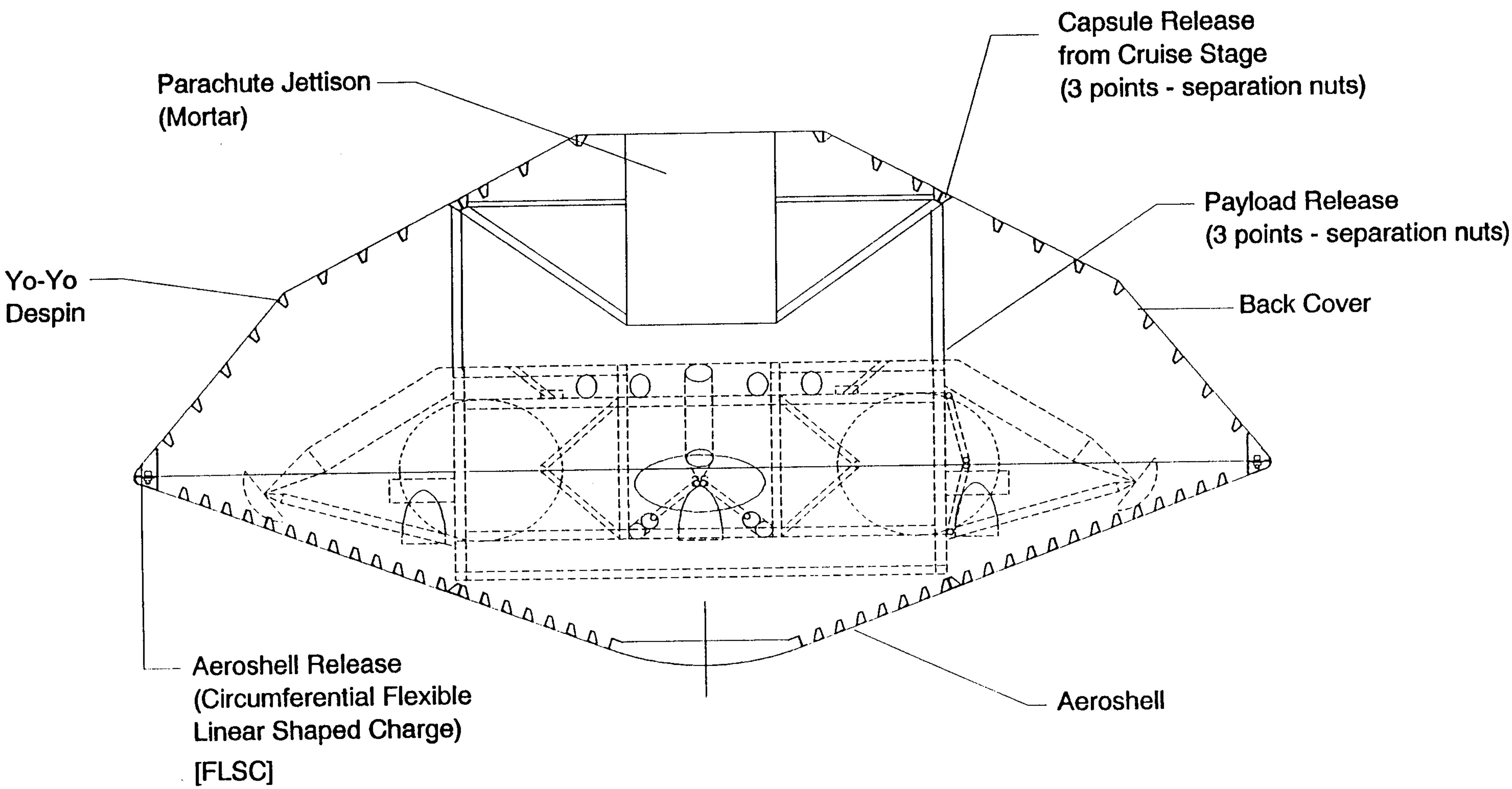
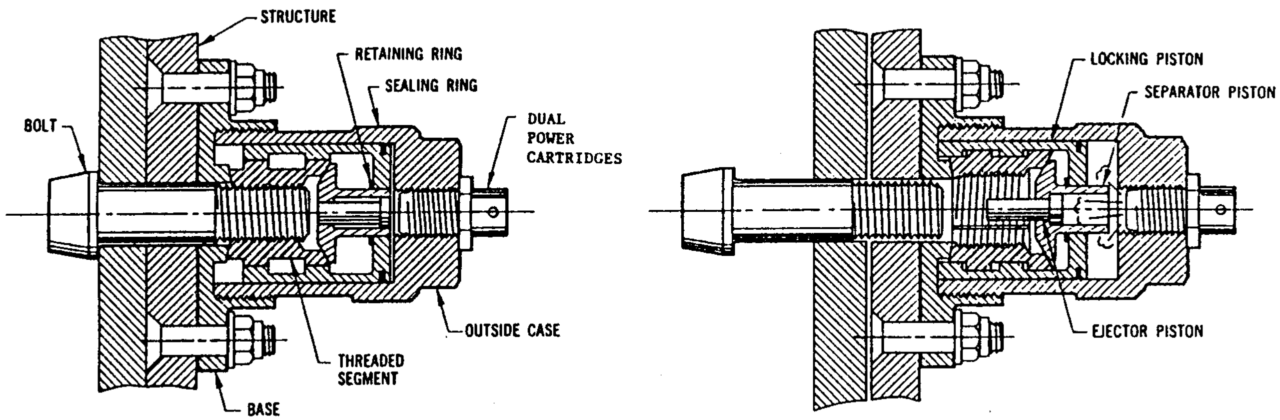


Figure 1.- MESUR Pathfinder pyrotechnic systems.

lb1
WRM 9/25/92

hi-shear CORPORATION / ORDNANCE DIVISION
TORRANCE · CALIFORNIA

HOW THE SN7300 SERIES NUT SEPARATES



INSTALLED

Bolt Torquing Type Shown

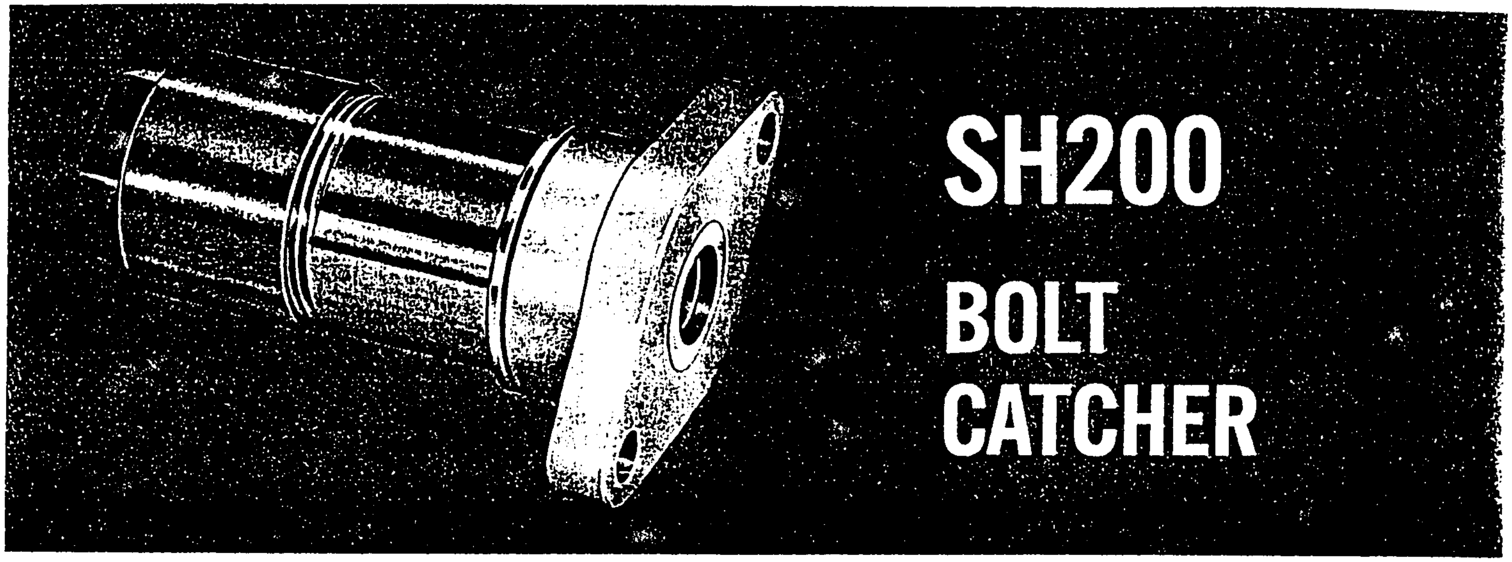
SEPARATED

1. Locking piston moves forward to unlock threaded segments.
2. Segments displace radially away from bolt.
3. Separator piston locks segments in open position.
4. Ejector piston thrusts bolt out of structure joint.

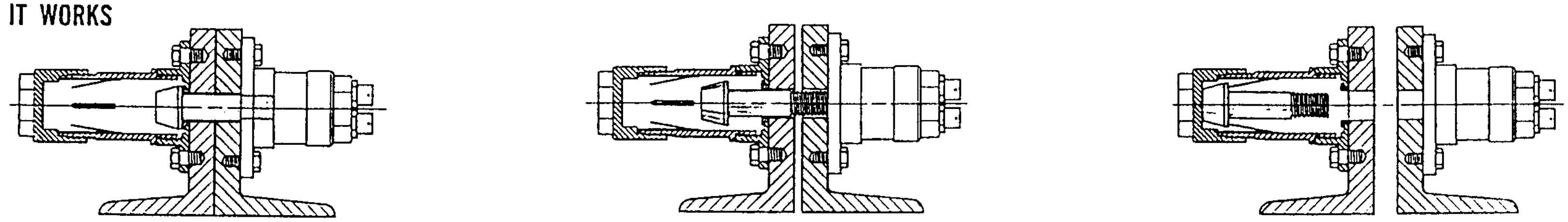
Figure 2.- Separation nut.

hi-shear CORPORATION *Ordnance Systems and Products*

data sheet



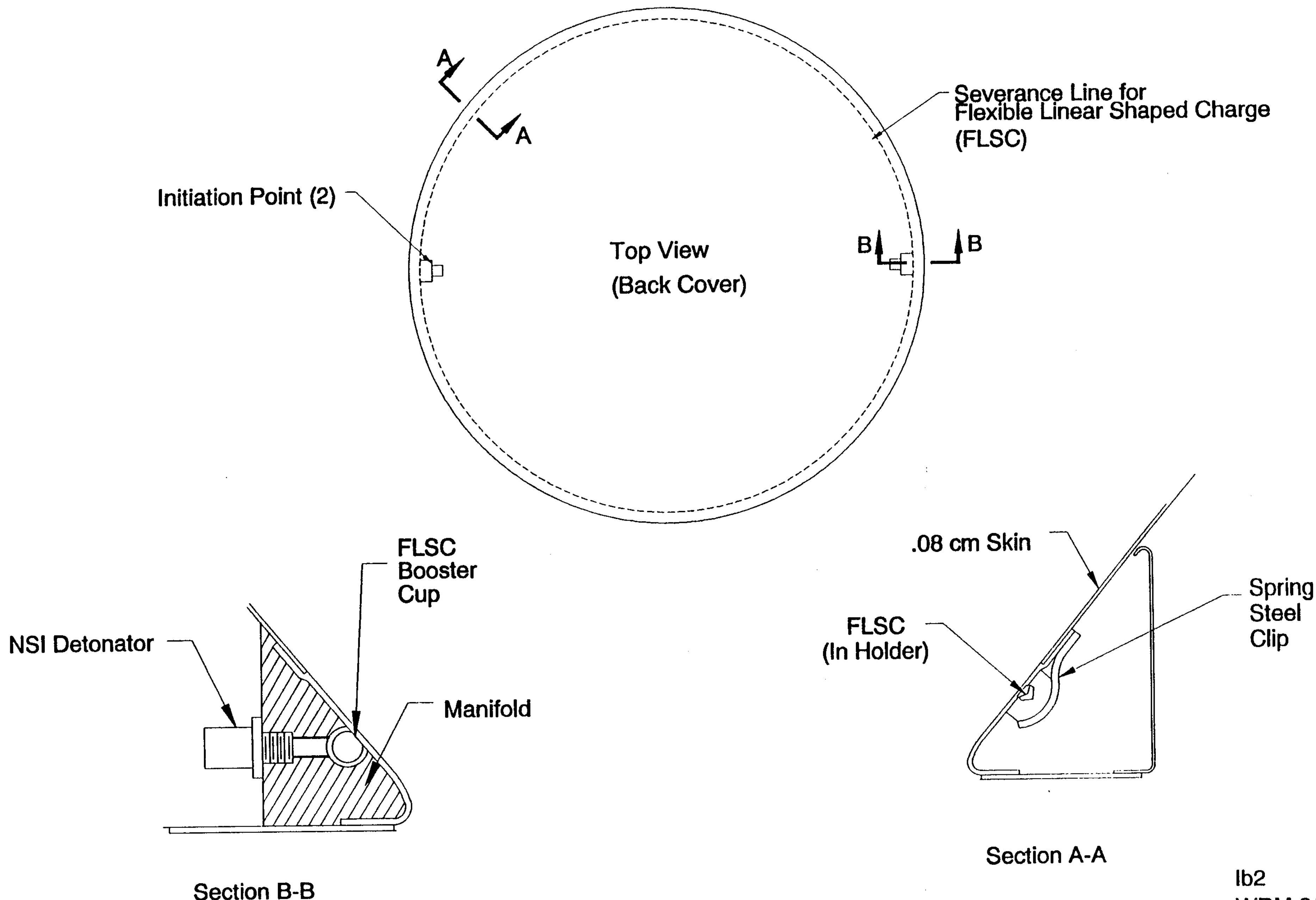
HOW IT WORKS



1. BOLT CATCHER INSTALLED, BEFORE SEPARATION.
2. BOLT MOVES BACK INTO CATCHER SLEEVE.
3. BOLT IS TRAPPED BY RETAINERS.

Figure 3.- Bolt catcher.

Pathfinder Aeroshell Release



lb2
WRM 9/25/92

Figure 4.- Pathfinder Aeroshell release.

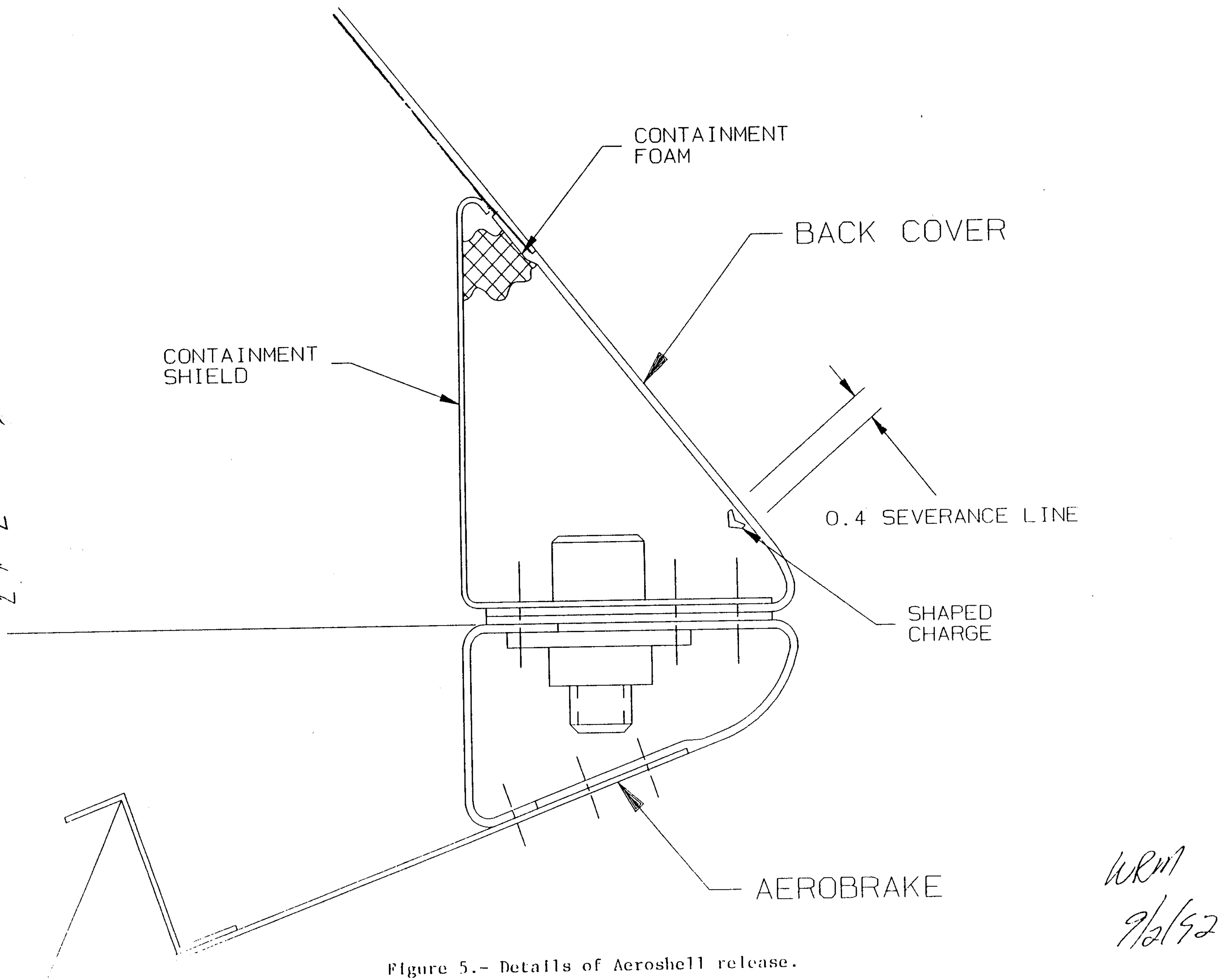


Figure 5.- Details of Aeroshell release.

QUALIFICATION EFFORTS REQUIRED FOR MESUR PATHFINDER PYROTECHNIC SYSTEMS

Approach - Efforts will be made to use qualified parts that meet the MESUR requirements. The previous qualification (functional performance and environmental survivability) will be compared to MESUR's needs and testing to meet the remaining needs will be accomplished in-house by NPS contract services. For example, few past programs have required the demonstration of functional performance margins; the energy deliverable by the pyrotechnic energy source must be at least three times greater than the energy required to accomplish the function. Environmental testing will be conducted in-house, witnessed by the manufacturers. Only ten units are planned for environmental exposure, which is a small sample. This small number is justifiable, since the devices will be well characterized, prior to environmental exposure, providing a performance criteria to assure survivability. Each of the components selected and described in a document, MESUR PATHFINDER PYROTECHNIC SUBSYSTEMS, dated September 11, 1992, will have their qualification approach described here.

There are no Phase B developmental or qualification issues. Existing facilities are adequate for qualification.

1. Cruise Stage separation - A standard separation nut will be selected that meets the requirements for separation from both the Cruise Stage and the Lander. All nuts required for the program will be purchased; portions of the group will be used for development, environmental qualification, system demonstration and flight, as shown in the attached table. Margin demonstration tests will consist of drop tests of a small (1 to 3-pound) weight onto the mechanisms of the nut to determine the energy required to accomplish release and bolt jettison. A new cartridge, the NASA Standard Gas Generator (NSGG), currently under development at LaRC will be used as the energy source. The energy deliverable from the cartridge will be determined by measuring the ejection velocity of the bolt. Environmental testing will be conducted to demonstrate the survivability of the assembly. Nut, bolt catcher and NSGG.

   System demonstration tests must be conducted to verify separation mechanics in which some energy is provided to assure separation (such as springs), particularly if pull-away electrical disconnects are incorporated as part of the separation interface. Pendulated boiler plate structure with mass simulations (to allow each half of the separation plane to swing apart horizontally) will be required to demonstrate the functional margin of separation. Pyrotechnic shock will be measured as system-level tests are conducted to determine the survivability of electronic packages.

2. Capsule despin - System developmental and qualification efforts will be described in a separate document. Functional margin tests of the Viking Standard Initiator (VSI) will be conducted in-house in the pin puller to be used to activate the mechanism to assure successful performance.

3. Aeroshell release -Functional margin will be demonstrated by explosively severing skin thicknesses at least 15 % greater than flight allowable. System level performance will be evaluated using arc lengths of the structure. Of particular importance will be the foam containment mechanism to reduce the potential of contaminating the Lander. A complete circumferential severance with at least simulated masses will be required. Environmental testing will be conducted on short (30 cm) lengths of the assembly.

4. Parachute jettison - Developmental and qualification efforts will be described in a separate document.

5. Payload release - The Lander release system demonstrations will be accomplished in the same manner as the Cruise Stage release.

<u>Test/Flight Assets Needed</u>

		Dev.	Qual.	Sys.	Flt.	Total
1,~~6~~5.	Separation (Cruise, Lander)					
	Separation Nut	12	10	9	10	41
	Bolt Catcher	4	10	9	10	33
	NSI Gas-Gen. Cartridges	28	20	12	18	78
2.	Pin Pullers					
	HALOE Bodies (GFE)	4	0	3	4	11
	VSI (GFE)	20	0	16	8	44
3.	Aeroshell Release					
	FLSC (ft) (GFE)	80				80
	Detonators		10	6	4	20
	Assemblies Sub/Full (FLSC, booster)		10/0	0/3	0/2	10/5

Laurence J Bement

Laurence J. Bement
Senior Pyrotechnic Engineer
September 14, 1992

ATTACHMENT 10

NAVAL CENTER

FOR

SPACE TECHNOLOGY

MPF-ARTS-7/92

Naval Research Laboratory
Washington, DC 20375-5000

Naval Center For Space Technology - History

- Origins Traceable To Vanguard Program (1955 - 1958)
- Satellite Techniques Branch Formed At NRL (1959)
- Continuing Spacecraft & Payload Development By NRL Branches & Divisions (1959 - 1981)
  - Major Space Program Developed By NRL
  - Major NRL Roles In Other Space Programs
- NRL Designed, Fabricated, Tested, Launched & Operated 78 Spacecraft
- NRL's Advanced Projects Office & Spacecraft Technology Center Merged To Form Space Systems Division (1981)
- Naval Center For Space Technology Established (1986)

Naval Research Laboratory
Washington, DC 20375-5000

NRL - Mission Statement

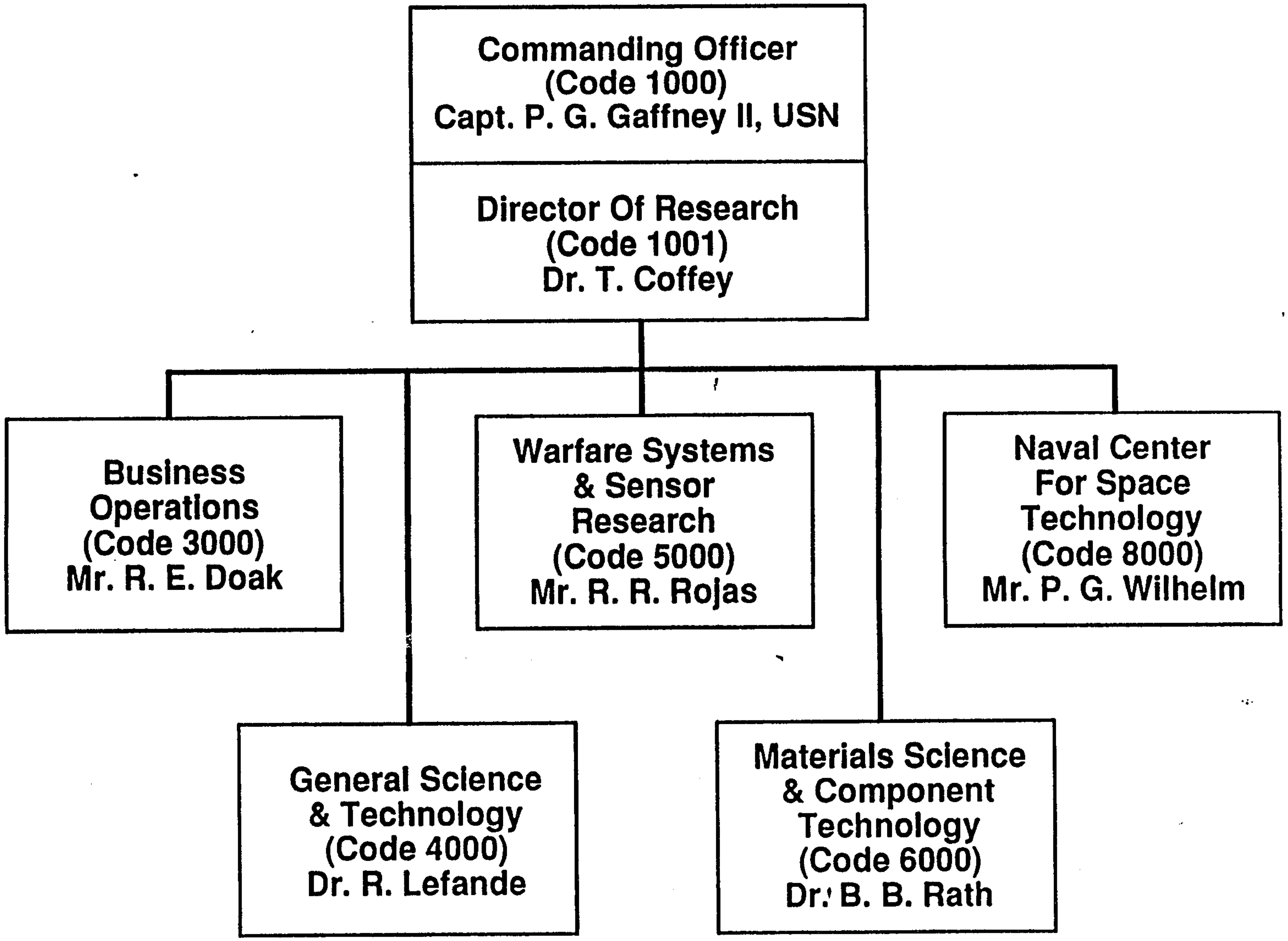
- To Conduct A Broadly Based Multi-disciplinary Program Of Scientific Research & Advanced Technological Research Toward New & Improved Materials, Equipment, Techniques, Systems & Related Operational Procedures For The Navy

- Responsible For Navy-Wide Leadership In:
  - Performing Primary In-House Research For The Physical & Engineering Sciences
  - Conducting Broadly-Based Exploratory & Advanced Development Programs In Response To Identified & Anticipated Navy Needs
  - Developing Space Systems For The Navy

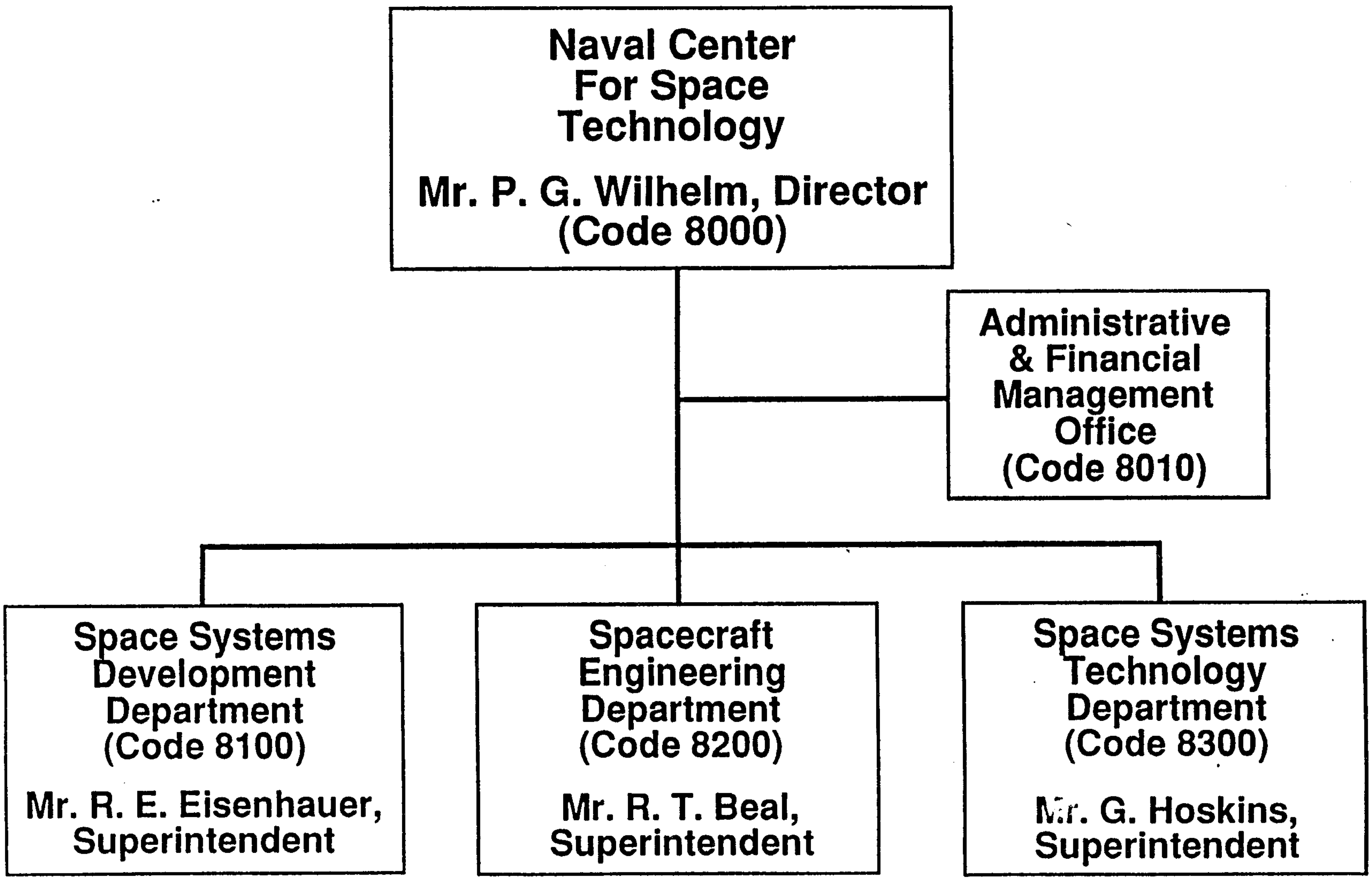
NCST - Mission

- NAVY's Lead Laboratory For Space
- Focal Point & Integrator For Other NRL Divisions To Assure Advanced Technologies Are Used In Space Systems
- Provides Expertise To:
  - Conduct Research & Development
  - Exploit New Technical Capabilities
  - Perform Systems Engineering
  - Test & Evaluate Selected Spacecraft
  - Analyze & Test Systems
- Develop Spacecraft Systems Using Spacecraft & Ground Control Stations
- Provide Systems Engineering & Technical Direction Assistance To System Acquisition Managers Of Major Space Programs
- Transfer Technology & Motivate A Continuous Search For New Technologies

NRL - Organization



Naval Center For Space Technology (NCST) Organization



NRL Satellite Launches (1 of 3)

LAUNCHES	SATELLITES	NAME	PURPOSE	WT.	VEHICLE	LAUNCH DATE	USEFUL LIFETIME	COMMENTS
1	1	SR I	Solar X-rays	42	THOR-ABLE-STAR	22 JUNE '60	10 MO.	FIRST SOLAR SATELLITE
2	2	SR II	Solar X-rays	40	THOR-ABLE-STAR	30 NOV '60	-	LAUNCH VEHICLE FAILED
3	3	LOFT I	Low Freq. Radio	57	THOR-ABLE-STAR	22 FEB '61	DECAYED 36 DAYS	NO SEPARATION
4	4	SR III	Solar X-rays	40	THOR-ABLE-STAR	29 JUNE '61	5 MO.	NO SEPARATION
5	5	SR IV A	Solar X-rays	66	THOR-ABLE-STAR	24 JAN '62	-	LAUNCH VEHICLE FAILED
	6	LOFTI II A	Low Freq. Radio	50	THOR-ABLE-STAR	24 JAN '62	-	
	7	SURCAL I	SPASUR Calib.	5	THOR-ABLE-STAR	24 JAN '62	-	
6	8	SR IV B	Solar X-rays	55	SCOUT	26 APR '62	-	LAUNCH VEHICLE FAILED
	9	SR V	Solar X-rays	-	-	-	-	NEVER LAUNCHED
7	10	PL 120	Classified	55	THOR-AGENA	13 DEC '62	36 MO.	OPERATION SATISFACTORY
	11	PL 121	Classified	55	THOR-AGENA	13 DEC '62	36 MO.	OPERATION SATISFACTORY
	12	SURCAL II	SPASUR calib.	9	THOR-AGENA	13 DEC '62	36 MO.	OPERATION SATISFACTORY
	13	CALSPHERE I	Object identification	3	THOR-AGENA	13 DEC '62	PASSIVE	DELAYED 6 MO.
8	14	SR VI	Solar X-rays	85	THOR-AGENA	15 JUNE '63	DECAYED 47 DAYS	OPERATION SATISFACTORY
	15	LOFTI II B	Low Freq. Radio	65	THOR-AGENA	15 JUNE '63	DECAYED 33 DAYS	OPERATION SATISFACTORY
	16	PL 112	Classified	60	THOR-AGENA	15 JUNE '63	DECAYED 42 DAYS	OPERATION SATISFACTORY
	17	Dosimeter	Radiation Counter	85	THOR-AGENA	15 JUNE '63	DECAYED 45 DAYS	OPERATION SATISFACTORY
	18	SURCAL III	SPASUR Calib.	9	THOR-AGENA	15 JUNE '63	DECAYED 19 DAYS	OPERATION SATISFACTORY
9	19	SR VII A	Solar X-rays	89	THOR-AGENA	11 JAN '64	23 MO.	OPERATION SATISFACTORY
	20	GGSE I	Grav. Grad. Exp.	84	THOR-AGENA	11 JAN '64	48 MO.	OPERATION SATISFACTORY
	21	PL 135	Classified	65	THOR-AGENA	11 JAN '64	21 MO.	OPERATION SATISFACTORY
10	22	DRAGSPHERE I	DRAG Exp.	2	THOR-ABLE-STAR	6 OCT '64	PASSIVE	OPERATION SATISFACTORY
	23	DRAGSPHERE II	DRAG Exp.	21	THOR-ABLE-STAR	6 OCT '64	PASSIVE	OPERATION SATISFACTORY
11	24	SR VII B	Solar X-rays	103	THOR-AGENA	9 MAR '65	52 MO.	OPERATION SATISFACTORY
	25	PL 142	Classified	106	THOR-AGENA	9 MAR '65	15 MO.	OPERATION SATISFACTORY
	26	GGSE II	Grav. Grad. Exp.	130	THOR-AGENA	9 MAR '65	44 MO.	OPERATION SATISFACTORY
	27	GGSE III	Grav. Grad. Exp.	130	THOR-AGENA	9 MAR '65	16 MO.	OPERATION SATISFACTORY
	28	SURCAL IV	SPASUR Calib.	10	THOR-AGENA	9 MAR '65	5 YEARS	OPERATION SATISFACTORY
	29	DODECAPOLE	Object Identification	9	THOR-AGENA	9 MAR '65	PASSIVE	OPERATION SATISFACTORY
12	30	TEMPSAT I	Thermal Design Exp.	19	THOR-ABLE-STAR	13 AUG '65	3 MO. DESIGN LIFE	OPERATION SATISFACTORY
	31	LONG ROD	Object Identification	6	THOR-ABLE-STAR	13 AUG '65	PASSIVE	OPERATION SATISFACTORY
	32	SURCAL V	SPASUR Calib.	11	THOR-ABLE-STAR	13 AUG '65	7 YEARS	OPERATION SATISFACTORY
	33	CALSPHERE II	Object Identification	8	THOR-ABLE-STAR	13 AUG '65	PASSIVE	OPERATION SATISFACTORY
	34	DODECAPOLE II	Object Identification	9	THOR-ABLE-STAR	13 AUG '65	PASSIVE	OPERATION SATISFACTORY

WNRL-G08

NRL Satellite Launches (2 of 3)

LAUNCHES	SATELLITES	NAME	PURPOSE	WT.	VEHICLE	LAUNCH DATE	USEFUL LIFETIME	COMMENTS
13	35	EXPLORER 30	Solar X-rays	125	SCOUT	19 NOV '65	24 MOS.	OPERATION SATISFACTORY
		SR VIII (PL 145)				18 MAR '66		50% SATISFACTORY
14	36	PL 137	H.F. Wave Prop.	90	ATLAS-AGENA		5 DAY DESIGN LIFE	
15	37	PL 151		115	THOR-AGENA	31 MAY '67	4 YEARS	OPERATION SATISFACTORY
	38	GGSE IV	Grav. Grad. Exp.	187	THOR-AGENA	31 MAY '67	5 YEARS	OPERATION SATISFACTORY
	39	PL 153	Grav. Grad. Exp.	169	THOR-AGENA	31 MAY '67	6 YEARS	OPERATION SATISFACTORY
	40	GGSE V	Grav. Grad. Exp.	231	THOR-AGENA	31 MAY '67	6 YEARS	OPERATION SATISFACTORY
	41	TIMATION I	Navigation	85	THOR-AGENA	31 MAY '67	24 MO.	OPERATION SATISFACTORY
	42	CALSPHERE III	Object Identification	10	THOR-AGENA	31 MAY '67	PASSIVE	OPERATION SATISFACTORY
	43	CALSPHERE IV	Object Identification	7	THOR-AGENA	31 MAY '67	PASSIVE	OPERATION SATISFACTORY
16	44	EXPLORER 37	Solar X-rays	197	SCOUT	5 MAR '68	6 YEARS	OPERATION SATISFACTORY
		SR IX (PL 155)						OPERATION SATISFACTORY
17	45	ORBIS CAL I	H.F. Wave Prop.	67	ATLAS-BURNER II	16 AUG '68	-	
18	46	ORBIS CAL II	H.F. Wave Prop.	85	ATLAS-OVI	17 MAR '69	7 DAY DESIGN LIFE	LAUNCH VEHICLE FAILED
19	47	PL 161	Grav. Grad. Exp.	220	THORAD-AGENA	30 SEPT '69	12 MOS.	VEHICLE POORLY ORIENTED
	48	PL 162	Grav. Grad. Exp.	223	THORAD-AGENA	30 SEPT '69	6 MOS.	OPER. SAT. TILL BATTERY FAIL.
	49	PL 163	Grav. Grad. Exp.	225	THORAD-AGENA	30 SEPT '69	3 YEARS	OPER. SAT. TILL CMD. SYS. FAIL
	50	PL 164	Grav. Grad. Exp.	227	THORAD-AGENA	30 SEPT '69	6 MOS.	OPERATION SATISFACTORY
	51	TIMATION II	Navigation	137	THORAD-AGENA	30 SEPT '69	6 YEARS	OPER. SAT. TILL CMD. SYS. FAIL
	52	PL 176	Classified	50	THORAD-AGENA	30 SEPT '69	2 YEARS	OPERATION SATISFACTORY
	53	TEMPSAT II	Thermal Design Exp.	30	THORAD-AGENA	30 SEPT '69	8 MOS.	OPERATION SATISFACTORY
	54	CONE	Object Identification	7	THORAD-AGENA	30 SEPT '69	PASSIVE	OPERATION SATISFACTORY
	55	CYLINER	Object Identification	5	THORAD-AGENA	30 SEPT '69	PASSIVE	OPERATION SATISFACTORY
20	56	PL 170A	Drag. Exp. (Gold Plate)	1.6	THOR-BURNER	16 FEB '71	PASSIVE	OPERATION SATISFACTORY
	57	PL 170B	Drag. Exp. (Polish. AL)	1.6	THOR-BURNER	16 FEB '71	PASSIVE	OPERATION SATISFACTORY
	58	PL 170C	Drag. Exp. Polish. AL)	1.6	THOR-BURNER	16 FEB '71	PASSIVE	OPERATION SATISFACTORY
21	59	EXPLORER 44	Solar X-Rays	263	SCOUT	8 JULY '71	7 YEARS	OPERATION SATISFACTORY
		SR X (PL 185)						OPERATION SATISFACTORY
22	60	PL 171	Grav. Grad. Exp.	271	THORAD-AGENA	14 DEC '71	8 YEARS	OPERATION SATISFACTORY
	61	PL 172	Grav. Grad. Exp.	271	THORAD-AGENA	14 DEC '71	-	OPERATION SATISFACTORY
	62	PL 173	Grav. Grad. Exp.	282	THORAD-AGENA	14 DEC '71	-	OPERATION SATISFACTORY
	63	PL 174	Grav. Grad. Exp.	282	THORAD-AGENA	14 DEC '71	-	OPERATION SATISFACTORY

WNRL-G09

NRL Satellite Launches (3 of 3)

LAUNCHES	SATELLITES	NAME	PURPOSE	WT.	VEHICLE	LAUNCH DATE	USEFUL LIFETIME	COMMENTS
23	64	TIM III/NTS-1	Navigation	1132	ATLAS-F	14 JULY '74	5 YEARS	OPERATION SATISFACTORY
24	65	SR IIA (PL 175)	Solar X-rays	403			15 MO.	OPERATION SATISFACTORY
	66	SR IIA (PL 177)	Solar X-rays	403	TITAN IIIC	14 MAR '76	40 MO.	OPERATION SATISFACTORY
25	67	MSD	Upper Stage/Dispenser	1299			41 DAYS	OPERATION SATISFACTORY
	68	181	Classified	432	ATLAS-F	30 APR '76	OPERATING	OPERATION SATISFACTORY
	69	182	Classified	432			OPERATING	OPERATION SATISFACTORY
	70	183	Classified	432			OPERATING	OPERATION SATISFACTORY
26	71	NTS-2	Navigation	1711	ATLAS-F	23 JUNE '77	OPERATING	OPERATION SATISFACTORY
27	72	MSD	Upper Stage/Dispenser	1299			31 DAYS	OPERATION SATISFACTORY
	73	191	Classified	432	ATLAS-F	8 DEC '77	OPERATING	OPERATION SATISFACTORY
	74	192	Classified	432			OPERATING	OPERATION SATISFACTORY
	75	193	Classified	432			OPERATING	OPERATION SATISFACTORY
28	76	LIPS I	Devel. Test Exp.	102	ATLAS-F	8 DEC '80	-	LAUNCH VEHICLE FAILED
29	77	LIPS II	Devel. Test Exp.	123	ATLAS-H	9 FEB '83	OPERATING	OPERATION SATISFACTORY
30	78	LIPS III	Solar Cell Exp.	138	ATLAS-H	15 MAY '87	OPERATING	OPERATION SATISFACTORY
31	79	LACE	Laser Experiment	3175	DELTA II	14 FEB '90	OPERATING	OPERATION SATISFACTORY
32	80	TLD	Upper Stage/ Satellite Dispenser	16000	TITAN IV	8 JULY '90	OPERATING	OPERATION SATISFACTORY

WNRL-G10

Naval Research Laboratory
Washington, DC 20375-5000

Advanced Release Technologies (ARTS)

Program Objectives & Plan

October, 1992

B. Purdy & M. Fratta

Naval Research Laboratory
Washington, DC 20375-5000

ARTS - Program

INTRODUCTION:

- **The ARTS Program Will Develop, Test & Demonstrate Laser Initiated Ordnance & Nitinol Driven Release Mechanisms For Satellite Applications**
- **The Two Phase Program Will Result In An Experiment Flight In 1994/1995**
- **The Naval Research Laboratory Has Contracted EBAC To Design & Build The Laser Ordnance System**
  - **Contracts For The Nitinol Mechanisms Have Been Let To TiNi & Boeing**
- **A Multiple Output Laser Diode Firing System, Energy Transfer System (ETS), & Laser Initiator (NSI Equivalent) Will Be Validated In Orbital Environments**
- **NRL & NASA Coordination May Provide Useful Technology Transfers For Current & Future Space Applications**

ARTS - Objectives

Flight Demonstration Of Advanced Release Technologies:

- **Integrate & Qualify Mature Technologies**
  - **Demonstration Of Proven Technology Reduces Technical Risk**
  - **Experiment Philosophy Controls Cost**
- **Quantify Benefits Of Technologies For Program Spacecraft**
  - **Simplify Release Systems**
  - **Reduce Weight**
  - **Reduce Shock**
- **Gain Knowledge Base On Technology Application In Space**
- **Minimize Experiment's Impacts On Satellite & Integrating Contractor**

ARTS - Benefits

BENEFITS:

- *Laser Initiated Ordnance*:
  - Weight/Size Reductions Of $\geq 50\%$
  - Simplified Firing System & Reduced Harness Complexity
  - \+ Reduced Safety Concerns Of Static & EMI
  - \+ Eliminates Extensive System EMI Tests
  - Simplifies Ground Processing - No Stray Voltage & Bridgewire Tests
- *Nitinol Mechanisms*
  - Non-Explosive, High Strength Release Mechanisms
  - Improved Reliability & Much Lower Pyroshock Environment
  - \+ Eliminates Safety Concerns Of Explosives
  - \+ Simple Electrical Control

+ Features Reduce System Costs

ARTS - Program Plan

PHASE I

- Industry Survey (Completed)
- Development, Optimize & Test Prototype Hardware (In Process)
- End Products:
  - 1 Laser System Characterized
  - 3 Nitinol Release Mechanisms Characterized

PHASE II

- Build & Qualify Components Using Phase I Experience
- Design, Build, Test, & Integrate Flight Experiment Hardware
- Transfer Technology To Flight Programs
- End Products:
  - 1 Flight Proven Laser System
  - 1-3 Flight Proven Nitinol Release Mechanisms
  - Successful On-Orbit Experiment Operation

NBBR Req'ts: then could add to the experiment.

ARTS - Phase 1 Goals

PHASE I (Laser Ordnance)

- Design & Build 4 Channel "Demonstrator" LFU To Meet NRL Requirements
  - Demonstrator LFU Should Use Designs, Parts, Materials & Processes That Can Be Easily Transferred To Flight Configuration
- To Gain A Complete Understanding Of All Design, Manufacturing & Test Parameters
- Develop Test Criteria for Evaluating Future Flight Designs

Naval Research Laboratory
Washington, D.C.

ARTS - Phase 2 Goals

PHASE 2 (Laser Ordnance)

- Apply Knowledge Gained In Phase 1 To Produce Flight Qualified Unit
- Flight Unit Should Incorporate Designs Most Likely To Be "Accepted" By Range Safety
- Demonstrate On-Orbit Operation

PHASE 2 OPTIONS

- NRL ARTS Program (300K) 93 set aside
- NASA Programs
- SDI Programs - Techsat, etc

ARTS - Experiment Description

- **The ARTS Experiment Interfaces With Host Spacecraft**
  - **Emphasis On Ease Of Integration & Low Risk To Host**
  - **All Components Housed In NRL's "Standard Box" Package**
- **Experiment Uses Standard Power, Command & Telemetry Interfaces**
- **Experiment Comprised Of:**
  - **Four-Channel Laser Diode Initiated Ordnance System**
  - ***Frangibolt* Non-Explosive Release Mechanism (2 Each)**
  - ***Bolt-Release* Non-Explosive Release Mechanism (2 Each)**
  - ***Fusible Link* Non-Explosive Release Mechanism (2 Each)**

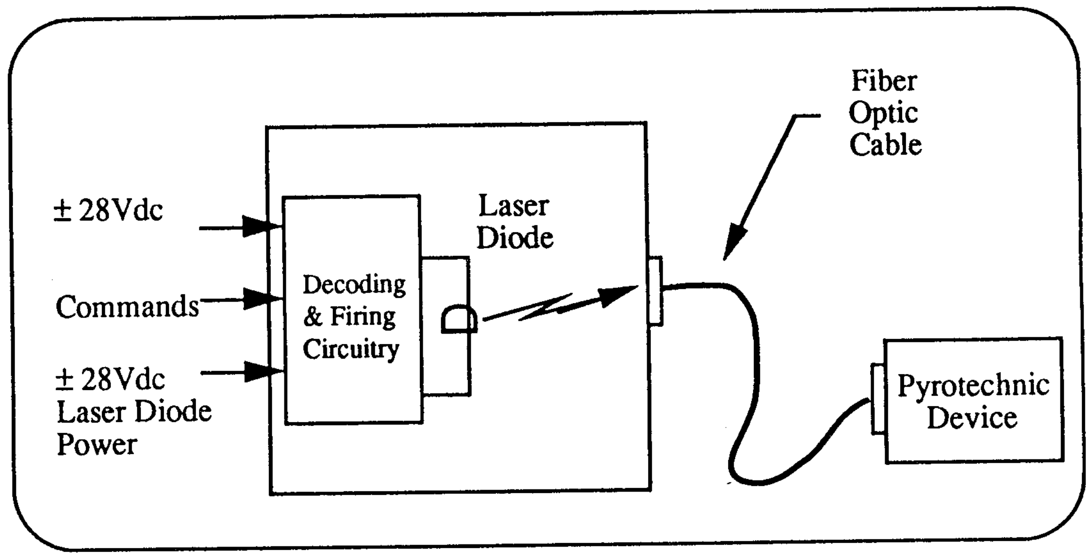
ARTS - Laser Initiated Ordnance Overview

DESCRIPTION:

- Fires Pyrotechnic Initiators With Energy Emitted By Laser Diode vs. Electrical Energy Of Conventional Systems
- Energy Directed By Fiber Optic Cables vs. Copper Harnesses

ADVANTAGES:

- Lower Weight Over Conventional System
- Fiber Optic Harness Not Susceptible To Stray Voltages Or EMI
- Reliability - Fewer Mechanical Components
- Reduces Safety Constraints



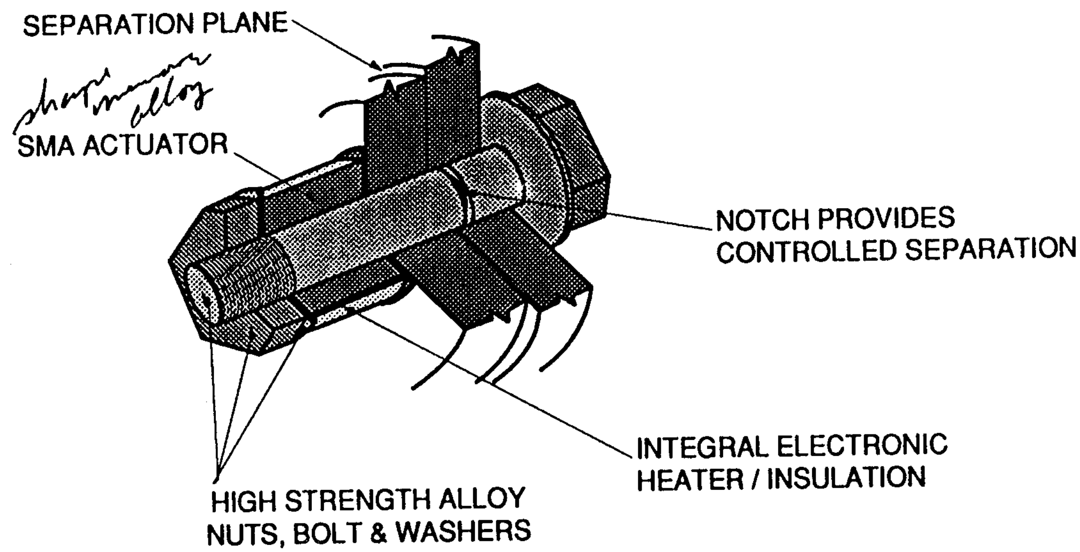
ARTS - *Frangibolt* Overview (1 of 2)

DESCRIPTION:

- Shape Memory Alloy Actuator To Break Bolt In Tension
- 28 Vdc Heater Drives Actuator Which Elongates When Heated
- Notched Bolt Stretches Until It Fails At Notch (Controlled Breakage)

ADVANTAGES:

- Much Lower Pyroshock
- Improved Reliability
  - No Sliding Friction
  - No Explosive Charge
- Safer Design Due To Elimination Of Explosives
- Reduced Ground Flow Testing & Handling
- Simplified Control Electronics



ARTS - *Frangibolt* Overview (2 of 2)

SHAPE MEMORY ALLOYS:

- Returns To Known Shape When Heated Above Transition Temperature
  - Reliably Returns From 5% Deformation (50,000 psi Pressure)
  - Work Output Drives Mechanisms & Supports Million's Of Cycles
  - Transition Temperature Can Be Tailored
  - Common & Available Titanium/Nickle Alloy

DESIGN:

- Shape Memory Alloy Actuator Sized To Give Large Force & Stroke Margin
- Bolt Sized To Assure Breakage At Notch & Assure Adequate Strength For Separation Joint
- Separation Time Is ~ 30 Seconds & Requires 3000 Watt-Seconds Of Energy

ARTS - Experiment Integration

- Use Release Devices To Deploy Small Mechanisms That Trigger Verification Switches
- Experiment Contains Two Of Each Type Of Mechanism
  - Allows An Operation Early In Mission & Another Later In The Mission
- Dedicated Experiment Box Contains Mechanisms & Drive Electronics
  - Contained Experiment Eliminates Risk From Device Malfunctions

ARTS Experiment Operation

- LFU EXPERIMENT:
  - Replace EED In Bolt Cutter With Laser Initiator
  - Initiate & Verify Operation Of Bolt Cutter
  - Use 1 Channel To Measure Laser Diode Output Performance Repeatedly Over Spacecraft Lifetime
- NITINOL EXPERIMENT
  - Activate & Verify Operation Of *FRANGIBOLT* Release Mechanism
  - Activate & Verify Operation Of *BOLT-RELEASE* Mechanism
  - Activate & Verify Operation Of *FUSIBLE LINK* Mechanism

ATTACHMENT 11

OSMQ

PAS Program Introduction

Norman R. Schulze
Langley Research Center
December 9, 1992

Meeting Contents

OSMQ

- Status
- Project by project summary:
  report by project managers

C-2

Status

OSMQ

- New focus:
  - standards and manuals
  - not hardware
- FY93
  - Manual
  - Data Base
  - Modeling
- Laser initiated ordnance:
  - Ensign Bickford contract near signing
  - specification work for safe and arm placed on hold
- Workshop
- Currently funded projects to be completed

Issues

OSMQ

- Perform modeling of the linear separation system?
- Workshop plans?

Pyrotechnics

OSMQ

NASA Pyrotechnically Actuated Systems Manual ($90K FY93)

- Project: A detailed "how-to" document will be prepared which will provide guidance to designers, management, and systems engineers on all aspects of design, development, demonstration: environmental qualification, acceptance testing, and margin demonstrations of pyrotechnically actuated devices and systems. The document's scope will cover the pyrotechnic life cycle from the initial component design and system design to the final disposition of the hardware.
- Product: NASA Pyrotechnically Actuated Systems Design and Operations Guidelines

Pyrotechnics

OSMQ

NASA Pyrotechnically Actuated Systems Data Base ($60K FY93)

- Project: This Project continues the development of a user friendly computer data base system to provide the documentation of past and current programs' pyrotechnic system requirements, designs, performance, lessons learned, and qualification status. The data base content will ultimately includes data, reports, specifications, documents, etc. which will list technical data from all past and presently available pyrotechnic devices. Development of the data base will be through interactions with NASA Centers, various DOD and DOE organizations, and private industry. Initial entries will be made and coordinated among the NASA users. Training will be provided to users.
- Product: NASA Pyrotechnically Actuated Systems Data Base and User's Manual .

NASA PYROTECHNICALLY ACTUATED SYSTEMS PROGRAM

Program Manager
NORMAN SCHULZE
HEADQUARTERS

Program Requirements & Assessments

- 1.1 Future Pyro Requirements
  N. Schulze, Hqs.
- 1.2 Pyrotechnic Policy
  N. Schulze, Hqs.
- 1.3 PAS Technical Specification
  B. Wittschen, JSC
- 1.4 PAS Data Base & Appl. Catalogue
  T. Seeholzer, LeRC
- 1.5 Annual Review & Report
  N. Schulze, Hqs.
- 1.6 Program Implementation Plan
  N. Schulze, Hqs.
- 1.7 NASA PAS Manual
  L. Bement, LaRC
- 1.8 Pyrotechnic Systems Workshop
  W. St. Cyr, SSC

Design Methodology

- 2.1 NASA Std. Gas Generator
  L. Bement, LaRC
- 2.2 Standard System Devices
- 2.2.1 NASA Std. Lin. Sep. Sys. (NSLSS)
  J. B. Davis, MSFC
- 2.4 NASA Std. Laser Safe and Arm
  B. Wittschen, JSC
- 2.5 Adv. PAS Performance
- 2.5.1 NASA Std, Laser Detonator
  B. Wittschen, JSC
- 2.5.2 NASA Std, Laser Initiator
  TBD

Test Techniques

- 3.1 NSGG Performance
  L. Bement, LaRC
- 3.2 Standard Systems
- 3.2.1 NASA Std. Lin. Sep. Sys. (NSLSS)
  L. Bement, LaRC
- 3.4 Safe & Arm Performance
  B. Wittschen, JSC
- 3.6 Service Life Aging Eval.
  L. Bement, LaRC
- 3.6.1 Shuttle Service Life Aging Eval.
  L. Bement, LaRC

Process Technology

- 4.2 NASA Standard Initiator Model
  R. Stubbs, LeRC

ATTACHMENT 12

ENSIGN BICKFORD AEROSPACE

Ensign Bickford Aerospace Company
P.O. Box 427
Simsbury, Connecticut 06070
203 / 843-2630
FAX: 203 / 843-2621

September 2, 1992
REPLY TO:92-1625:HGC

Mr. Daniel J. Goldin, Administrator
NASA Headquarters
Office of the Administrator
Washington, D.C. 20546

Subject: NASA Leadership in New Technology Development

Dear Mr. Goldin,

In a letter to Mr. Truly last year, I noted the efforts of Mr. George Rodney in implementing new technologies to improve the performance of aerospace vehicles while reducing costly NASA documentation requirements. I believe these efforts have been an excellent start toward what Mr. Rodney intended and I have confidence Mr. Fredrick Gregory will continue them.

The ordnance community is now provided with a Pyrotechnic Program coordinated by the Office of Safety and Mission Quality - Technology program which has already been key in unifying the requirements of the different geographical ranges as they address laser safe and arm requirements.

Ensign Bickford Aerospace Company has been an industry leader in the production of ordnance products for space applications for over 40 years. Through longstanding efforts like the production of Confined Detonating Cord for Saturn/Apollo and now the Space Shuttle, we experience first hand the complex processes and procedures required for the handling of explosive ordnance.

For 15 years now we have developed laser and fiber optic technologies as safer, lighter, and less costly alternatives for existing ordnance systems. The capabilities of lasers offer enhanced manufacturing and operational flow for multiple aerospace vehicles. However, the transition from conventional ordnance to improved technology has often required overcoming the mind set of individuals continuing to impose outdated technical, and extensive documentation, requirements.

We have recently achieved success in this area thanks, in part, to the efforts of the Pyrotechnics Program. Through the initiative of the Technical Standards Division's program I am convinced we will be able to simplify the transition to improved technology and in turn help to optimize overall aerospace vehicle operations and performance.

We in industry look to NASA for just this type of initiative. If funding is maintained, the Pyrotechnic Program and similar enabling activities will provide a good,term return on investment.

Sincerely,

Hugh G. Caldwell
President & CEO

HGC/bjw

cc: R. J. Gilchrist
A. D. Rhea
H. G. Caldwell

ET, INC.
A SUBSIDIARY OF OEA
POST OFFICE BOX KK • FAIRFIELD, CA 94533-0659
TELEPHONE (707) 422-1880 • FAX (707) 422-3242

NOV 4 1992

2GBH-21011
26 October 1992

Frederick Gregory
Associate Administrator, Code Q
NASA Headquarters
Washington DC 20546

Dear Mr. Gregory:

ET, a subsidiary of OEA, Inc., is an industrial participant in the NASA Pyrotechnically Actuated Systems Program as the designer and manufacturer of an advanced spacecraft/launch vehicle separation joint that is to be evaluated by Marshall Space Flight Center and Langley Research Center. We are concerned about a possible decision to cancel this program. This type of program can help significantly by creating better defined products, systems requirements and specifications. More importantly, it will allow competition among different qualifying designs for various pyrotechnically actuated functions.

ET is a thirty-one-year-old aerospace company, currently employing 250 people, that thas had the opportunity to design and build many devices and subsystems for the manned space flight program (ET-provided items for the Saturn/Apollo and Space Shuttle projects are noted on the attached sheets). We feel that the output from this program can potentially have a far-reaching beneficial effect for the U. S. space program for years to come. I urge the continuance of this program.

Sincerely,

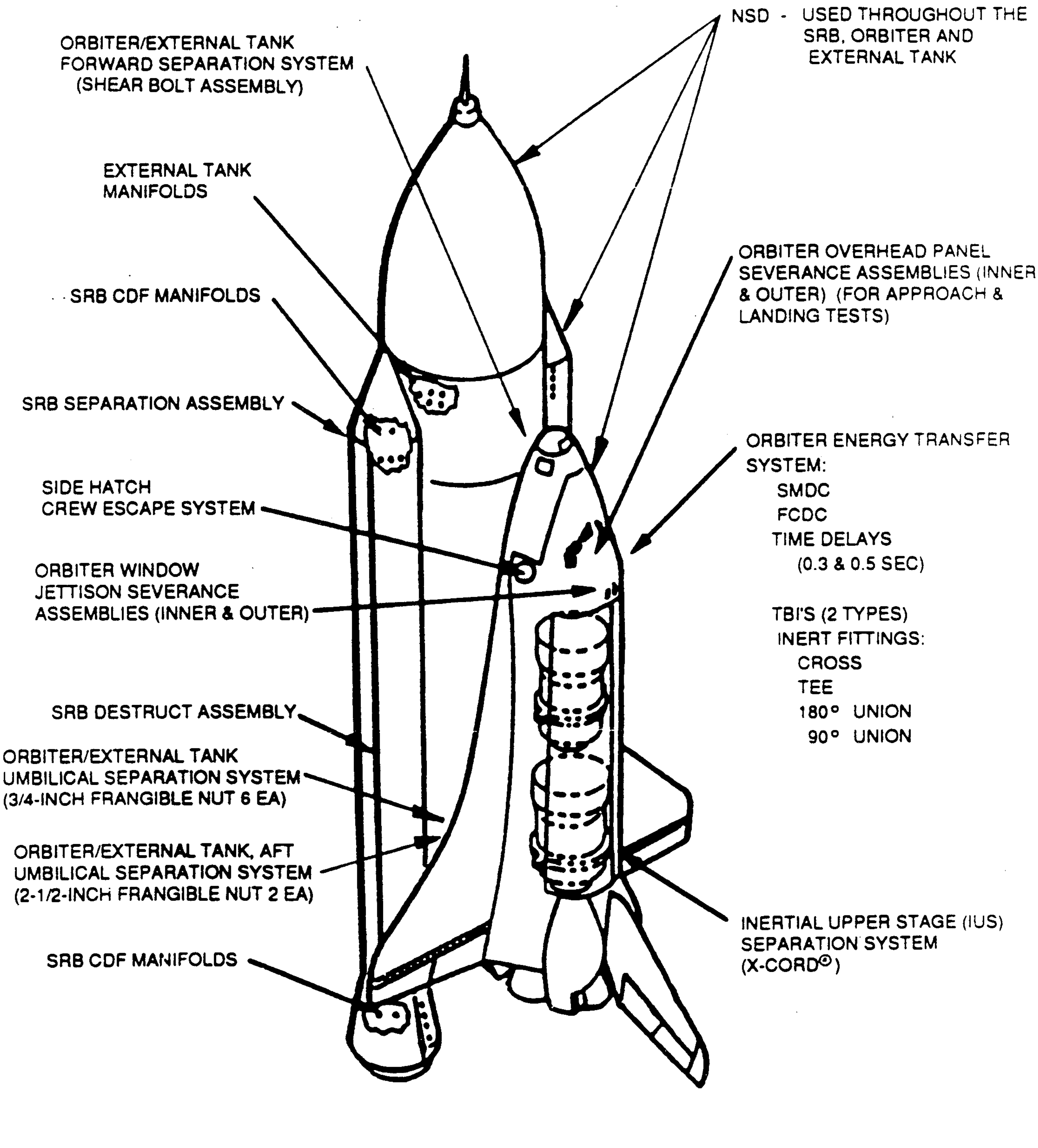
ET, INC.

G. Ben Huber
President

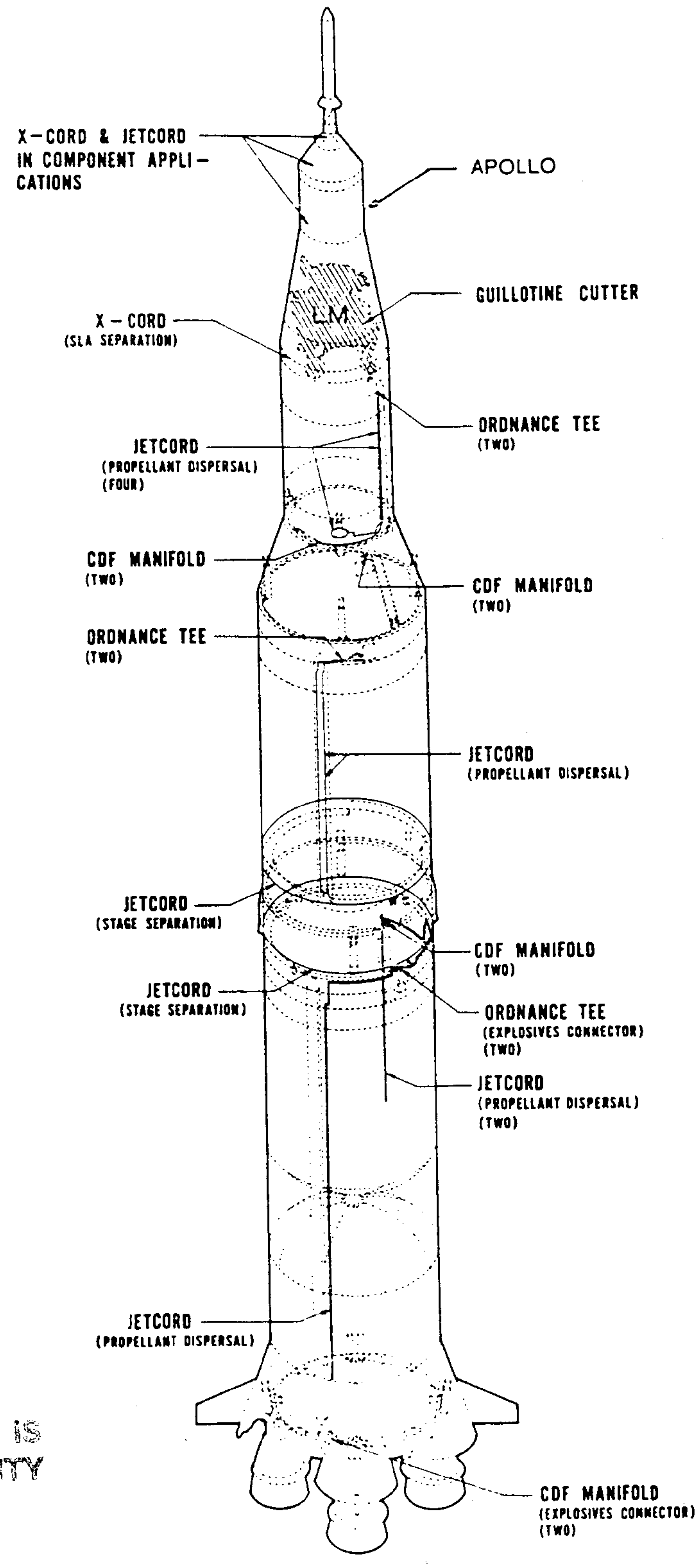
gh

Q92-1533

PRODUCTS FOR SPACE SHUTTLE



PRODUCTS FOR SATURN-APOLLO-LM



hi-shear TECHNOLOGY CORP
24225 GARNIER STREET • TORRANCE, CALIFORNIA 90505-5323 • U.S.A.
TELEPHONES: (310) 784-2100 FAX: (310) 325-5354

November 20, 1992

Federick Gregory
Associate Administrator, Code Q
NASA Headquarters
Washington, DC 20546

Dear Sir:

I understand that you are considering the termination of a Pyrotechnically Actuated Systems Program. Hi-Shear, as a manufacturer of Pyrotechnic devices, is currently involved in this Program. We are currently under contract to NASA LaRC to produce a gas generating cartridge to power a variety of pyrotechnic mechanisms. This cartridge would be known as the NASA Standard Gas Generator (NSGG). The approach is to modify the NASA Standard Initiator (NSI) to provide a gas output, rather than an initiation output. Since this cartridge has the potential to improve the performance and reliability of a wide variety of pyrotechnic mechanisms, we would like to request that you reconsider the decision to cancel this effort.

Hi-Shear has been in the ordnance business for over 30 years providing ordnance for space defense and underwater programs. Currently Hi-Shear is providing many ordnance devices for the Shuttle program, to include the NASA Standard Initiators (NSI) the forward and the aft Shuttle release bolts. To date Hi-Shear has produced over 35,000 NSI's and all release bolts for the Shuttle.

There are over 100 ordnance functions on the Shuttle and they all begin with the NSI. For many of those applications the NSI output by itself is inadequate for actuating the mechanical devices. In these cases we supply a booster to provide the additional energy required. The booster threads onto the NSI and is welded to the NSI through a shared weld washer. The disadvantages to this system are:

(1) The NSI to booster interface lowers the system reliability slightly.

(2) Three additional welds are required; one to weld the washer to the NSI, one to weld the washer to the booster and one for the booster closure weld. The washer welds are difficult to make and not easily leaked checked. There is no good way of verifying the integrity of the washer welds. The added welds, leak checks, and weight definitely cause an increase in cost.

TWX 910-347-7301 TELEX 664257

hi-shear TECHNOLOGY CORP.

Frederick Gregory
Pyro-Actuated Systems Program
20 November 1992
Page 2

The output of the NSI is primarily heat and metal oxides, which condense rapidly as the heat is dissipated. Therefore the peak pressure (working medium) decays very rapidly to give 95% solids. Since there is very little permanent gas (5%), this is not an ideal system for doing work, as actuating pin pullers, thrusters, etc. The NASA Standard Initiator was designed for initiating another pyro component which in turn would produce a higher percentage of gas.

The NSGG contains a heat producer and a gas producer all within the NSI body. The booster and initiator have been consolidated into one body to provide a much simpler and more reliable system. The increased output of the NASA Gas Generator (NSGG) (650 → 1000 psi), eliminates the need for a booster charge in those applicable cases.

This approach also provides considerable cost savings. The NSGG would cost approximately 10% more than a NSI but it will be 60% less than a combined NSI/booster.

We at Hi-Shear have worked to assure pyrotechnic technology is properly applied in the aerospace community. However, we have had to work from the "bottom up" with customers that often have very little experience and little supporting information or guidelines on how to apply pyrotechnics. This is the first time that we have seen an effort to coordinate pyrotechnic technology from the "top down" to help this situation and ultimately improve system reliability. Please reconsider canceling this effort.

Very truly yours,

Thomas R. Mooney

Thomas R. Mooney
President

TRM/HK/slh
(Pyroterm.Ltr)

ATTACHMENT 13

EXCELLENCE BY DESIGN

ENGINEERING DIRECTORATE

Lewis Research Center

Project 1.4

Pyrotechnically Actuated Systems

Database and Applications Catalog

December 8, 1992

NASA Lewis Research Center
Cleveland, Ohio

Prepared by: Paul Steffes
Analex Corp.
(216) 977-0123

PRESENTATION AGENDA

- Work Completed
- Planned Activities F'93
- Planned Activities F'94
- Revised Schedule for Project 1.4
- Issues

WORK COMPLETED

- Reduced input requirements on questionnaires to two pages per device and two pages per system.
- Database approach for entering and storing data established.

  - Need OMNIS 7 Database Package (not ordered to date) to complete.
- Entered some LeRC pyrotechnic devices into sample questionnaire and database. Redistributed questionnaires to all Centers in September 1992. Floppy disks were sent as required.

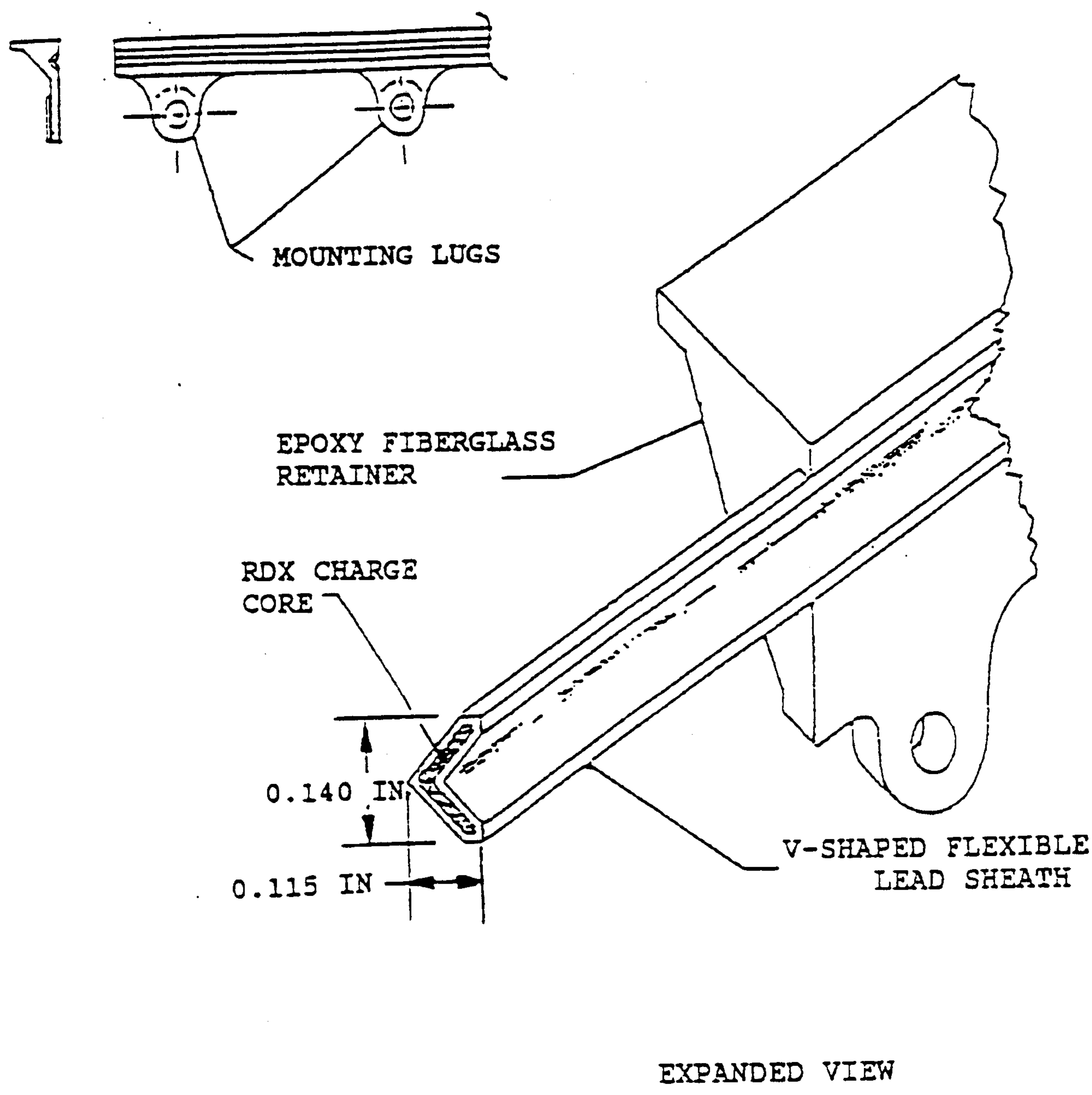
  - No answers received to date by Analex.
- Researched and obtained information on "Write Once" CD ROM technology. Current expectation of database size (F'93) suggests CD ROM may not be necessary.

NASA/DOD/DOE Pyrotechnic Device

Title: Flexible Linear Shaped Charge

Agency/Center: NASA LeRC

Physical Data:



FLEXIBLE LINEAR SHAPED CHARGE (FLSC)
15 GR/FT SIZE SHOWN

NASA/DOD/DOE Pyrotechnic Device

Contractor: General Dynamics Space Systems Division
Vendor: Ensign Bickford
Device identification number:
GDSSD 55-00211
Purpose:
To separate one structure from another by use of pyrotechnic energy linearly severing the part by the blast cutting action of the high temperature explosive jet focused by the chevron shape of the charge.

Previous Usage:
On Atlas Centaur Launch Vehicles through AC-68 for separation of Centaur from Atlas.

Operational Description:
The flexible linear shaped charge (FLSC) is chevron or inverted "V" shaped in section. Although activation causes outward force over 360 deg, the chevron shape concentrates a portion of the blast energy below the open end of the inverted "V". Over a length of FLSC, the focused energy becomes a linear high temperature jet for cutting action by melting/blasting through a structural attachment. A typical usage of this device is the 15 gr/ft size FLSC which, at a standoff of .025 in., produces a maximum cutting depth of .090 in. (Al alloy).

Activation of the FLSC is accomplished by use of an initiator(s) in conjunction with booster detonators and confined mild detonating fuse firing transfer lines as appropriate.

Energy Source:
Type of Initiation: Requires an initiator
Operational Description/Charge Materials:
Cyclotrimethylene Trinitramine (RDX)
Operating Temperature Range:
Low: -300 deg F **High:** 200 deg F

Operating Pressure:

Shock:

Vibration:

Electrical Characteristics:

Qualification Documentation:

Service Life
Shelf: No limitations.
Operational:

Additional Comments:

Special Features:

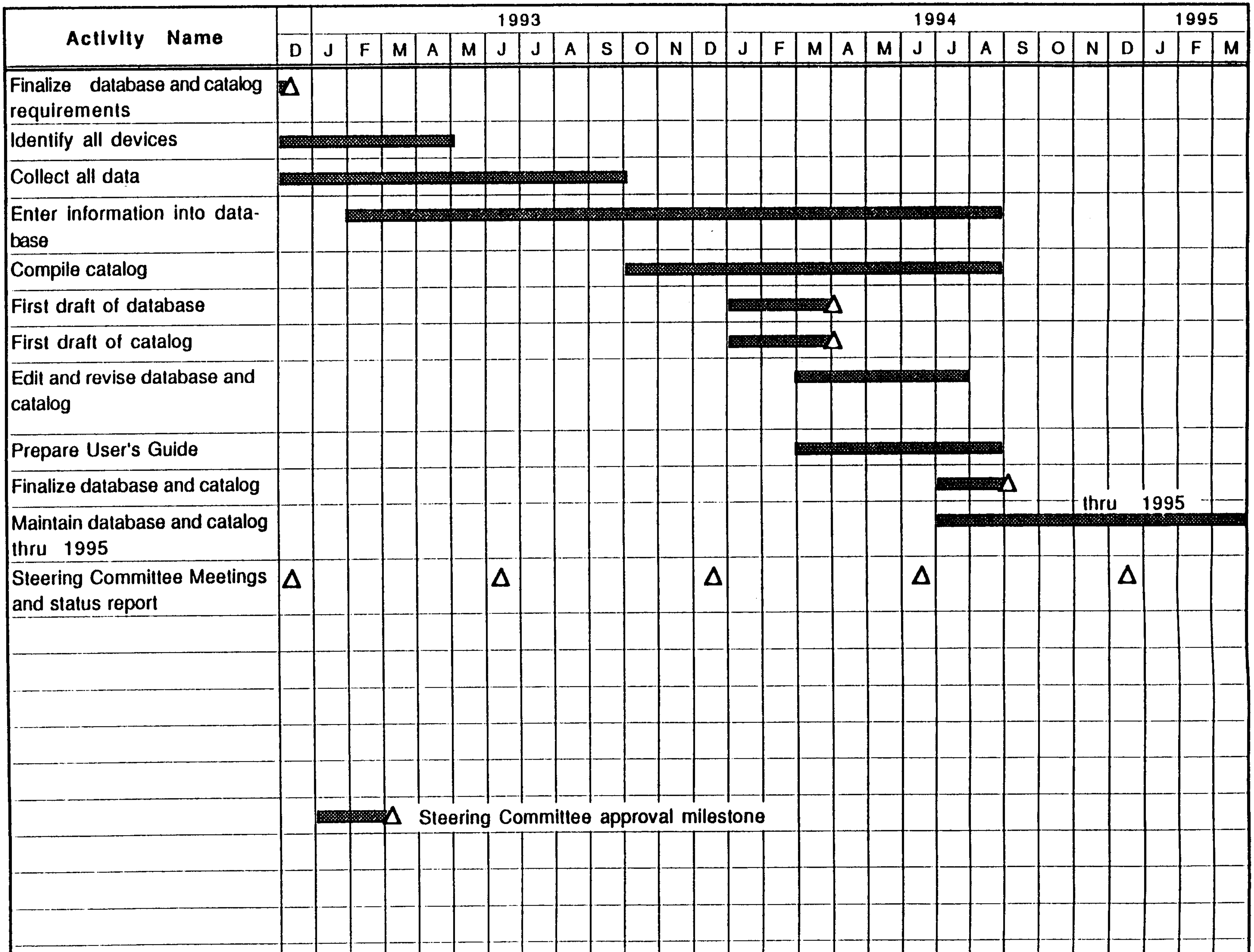
PLANNED ACTIVITIES F'93

- Call each center to determine if they have been able to develop their responses; determine if NASA HQ can be of assistance in obtaining responses.
- Procure remainder of OMNIS 7 Software.
- Continue programming database for user-friendly access and quick response time to sort/select queries.
- Incorporate available system and device information into database. No technical editing will be performed.
- Demonstrate database workability.
- Submit printed hard copy of database work completed to Pyrotechnic Steering Committee for comments.

PLANNED ACTIVITIES F'94

- Complete and distribute first draft of database for Committee comments.
- Complete and distribute first draft of catalog for Committee comments.
- Develop User's Guide.
- Finalize database, catalog and User's Guide.
- Schedules are contingent upon receipt of questionnaire responses from Agencies.

Schedule for Pyrotechnically Actuated Systems Database and Reference Catalog



rev. 12/3/92

ISSUES

- Questionnaire forms returned.
- Funding.

FUNDING STATUS

F'92 (complete)	$70,000
F'93 (funding due)	$60,000
F'94 (funding requirement)	$60,000

ATTACHMENT 14

PROPOSED PYROTECHNIC MANUAL

NASA LaRC

December 1, 1992

This manual will be constructed to assist design engineers and management in all aspects of the application of pyrotechnic devices: System approach, procurement, design, development, testing, demonstration of performance, integration into aerospace systems, qualification, acceptance testing, and disposal.

Table of Contents

VI. System Approach
- Compile system requirements
  * performance * schedule * cost
  * physical envelope * reliability * simplicity
  * management preference
- Compile history of similar past applications
- Negotiate/select approach and functions that most closely meet requirements
- Compile component performance requirements
- Determine integration approach

VII. Generate Performance-Based Specifications
- Describe approach to system
- Define system performance requirements
- Define component performance requirements
- Require demonstration of functional margin for components and systems, as contracted
- Require demonstration of environmental resistance
- Require acceptance performance demonstrations

VIII. Shelf and Service Life Evaluation

IX. Past Experience and Lessons Learned
- Examples of problems and solutions encountered at various levels of pyrotechnic design, development, qualification and application.

X. Disposal Methods

ATTACHMENT 15

DEVELOPMENT OF A NASA STANDARD GAS GENERATOR

- GOALS
- BACKGROUND
- APPROACH
- FEASIBILITY STUDY RESULTS
- FEASIBILITY STUDY CONCLUSIONS
- FUTURE PLANS

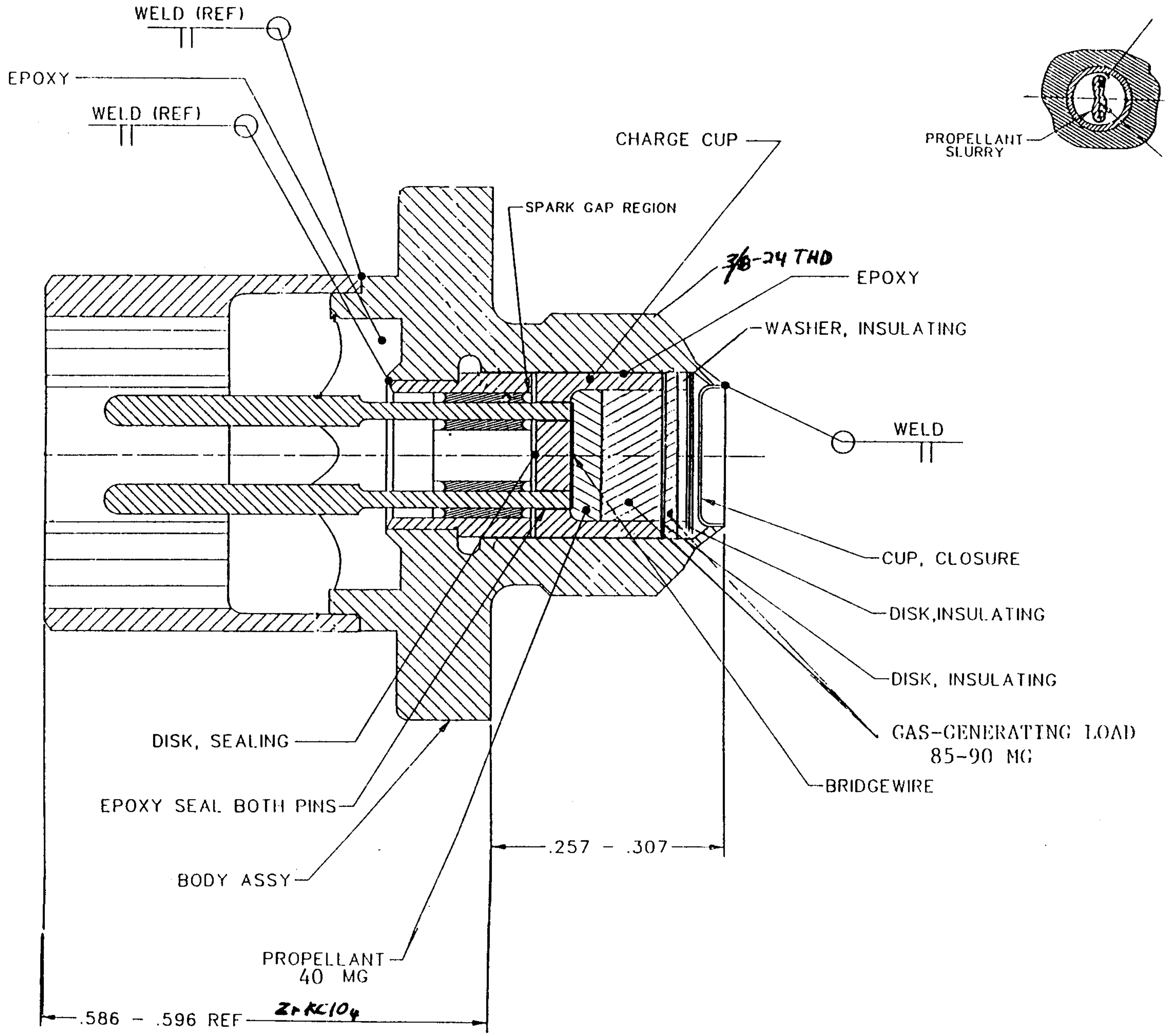
BEMENT/KARP/SCHIMMEL
6/9/92

NSGG GOALS

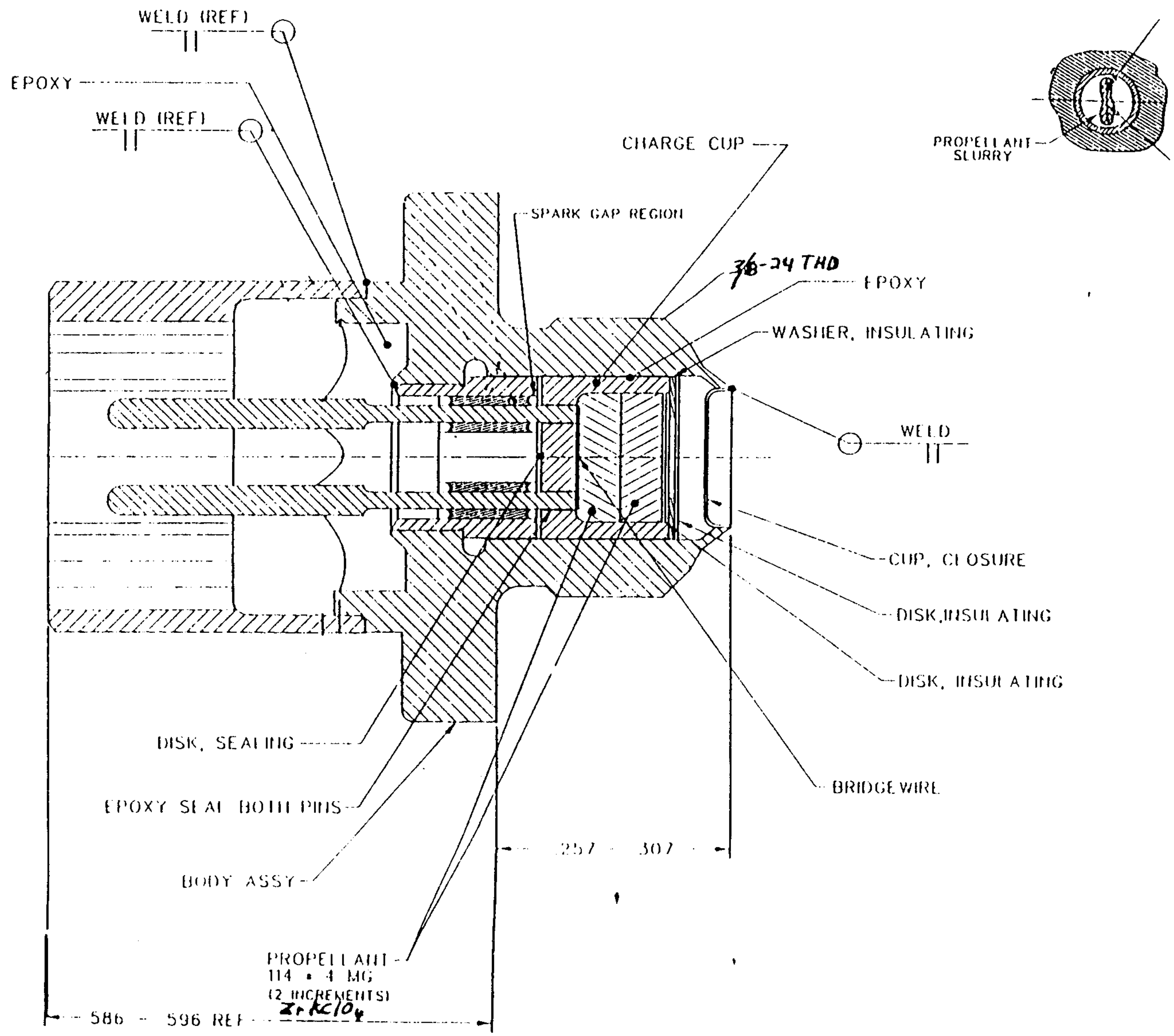
- DESIGN, DEVELOP, AND QUALIFY A NASA STANDARD GAS GENERATOR
  - SAME ENVELOPE AS NASA STANDARD INITIATOR (NSI)
  - HIGH THERMAL, VACUUM AND AGE STABILITY
  - CONSISTENT, RAPID-DELIVERY, GAS PRODUCTION
  - CAPITALIZE ON NSI QUALIFICATION
    - MAINTAIN STRUCTURE AND ELECTRICAL IGNITION INTERFACE
    - MODIFY PYROTECHNIC LOAD
    - CONDUCT DELTA-QUALIFICATION
- CHARACTERIZE OUTPUT PERFORMANCE FOR A VARIETY OF APPLICATIONS
- MAKE NASA STANDARD GAS GENERATOR GFE, LIKE NSI

BEMENT/KARP/SCHIMMEL
6/9/92

NASA STANDARD GAS GENERATOR



NASA STANDARD INITIATOR (NSI)



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APPROACH FOR NSGG DEVELOPMENT/QUALIFICATION

- DEVELOP EVALUATION TEST METHODS
- CONDUCT FEASIBILITY STUDY
- CONDUCT PRELIMINARY DEVELOPMENT
- CONDUCT FINAL DEVELOPMENT
- CONDUCT DELTA-QUALIFICATION

BEMENT/KARP/SCHIMMEL
6/9/92

CHARACTERIZATION OF NSGG OUTPUT

- OUTPUT OF ANY PYROTECHNIC CARTRIDGE DEPENDS ON HOW IT IS APPLIED

- WHY FOUR OUTPUT TEST METHODS?

  - CLOSED BOMB (10 CC)
    * UNIVERSALLY ACCEPTED STANDARD
    * DOES NOT SIMULATE ANY PYROTECHNIC DEVICE

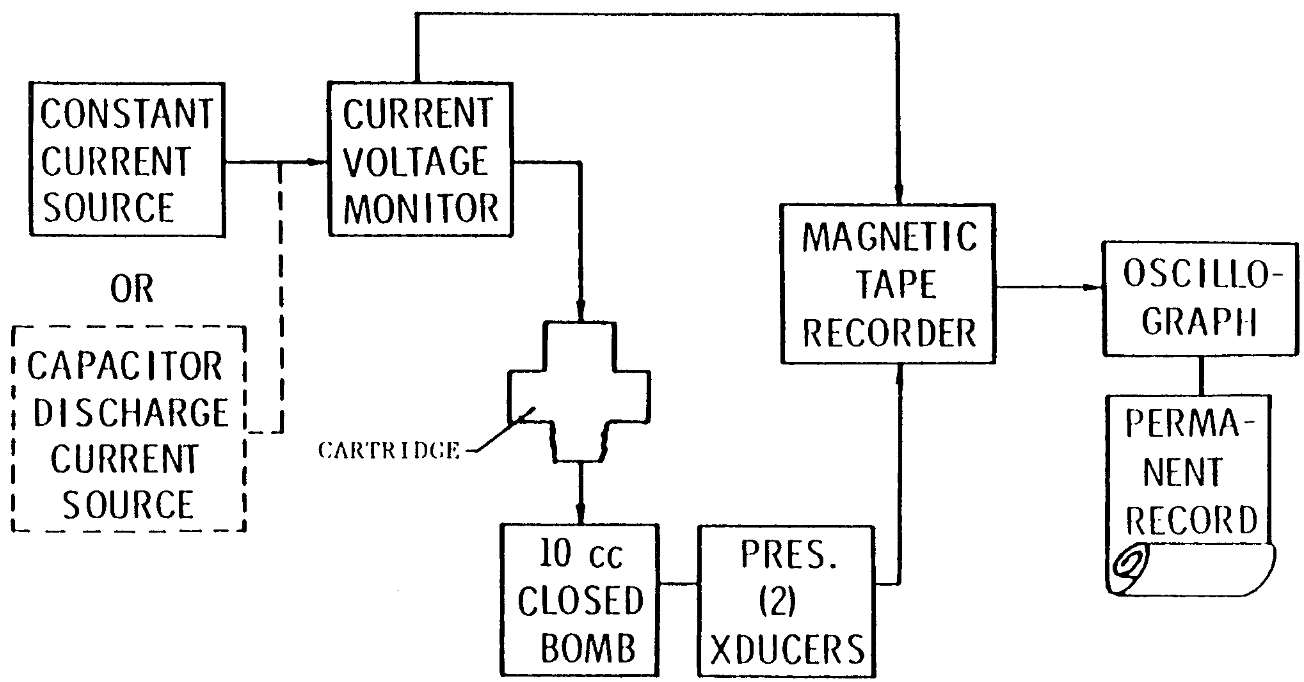
  - DYNAMIC TEST DEVICE
    * SIMULATES AN EJECTOR

  - MCDONNELL ENERGY SENSOR
    * SIMULATES THRUSTER ACTING AGAINST A CONSTANT RESISTANCE

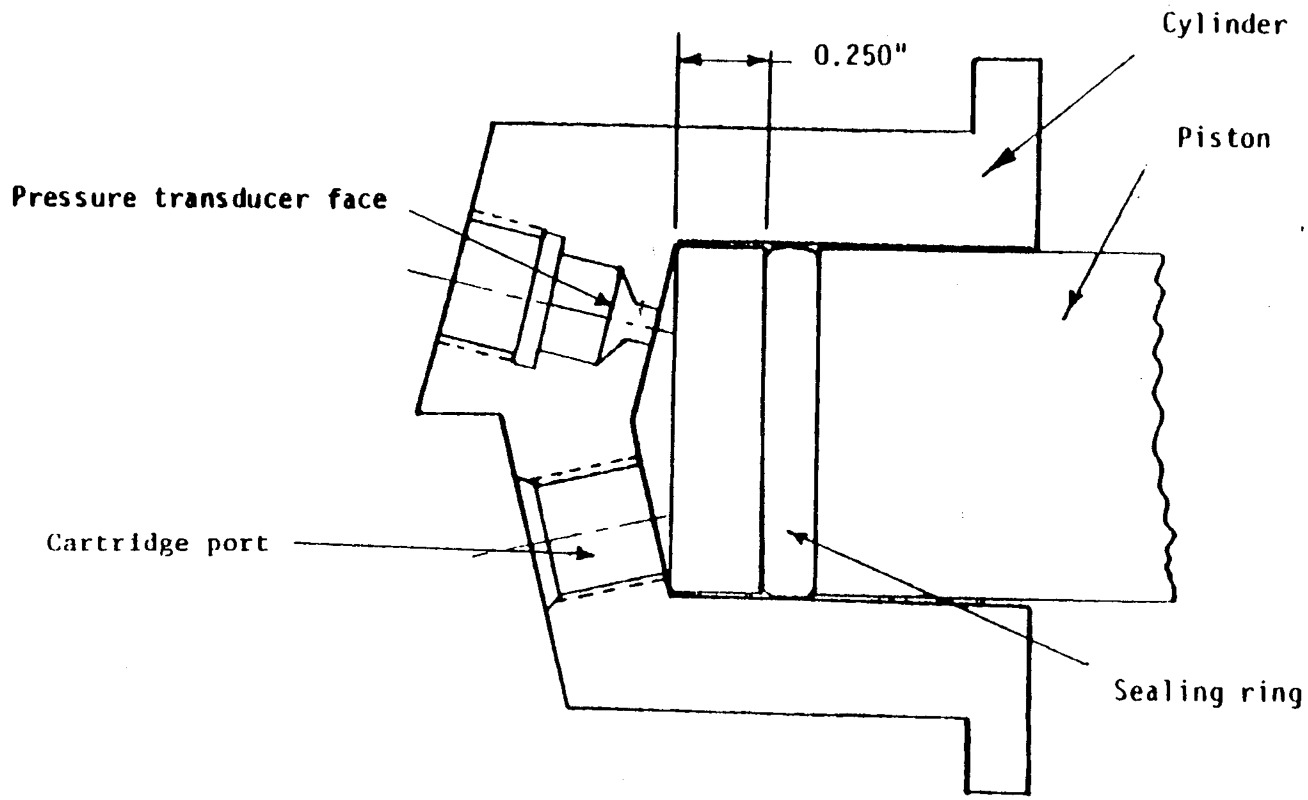
  - HALOE PIN PULLER
    * SIMULATES A RETRACTOR

BEMENT/KARP/SCHIMMEL
6/9/92

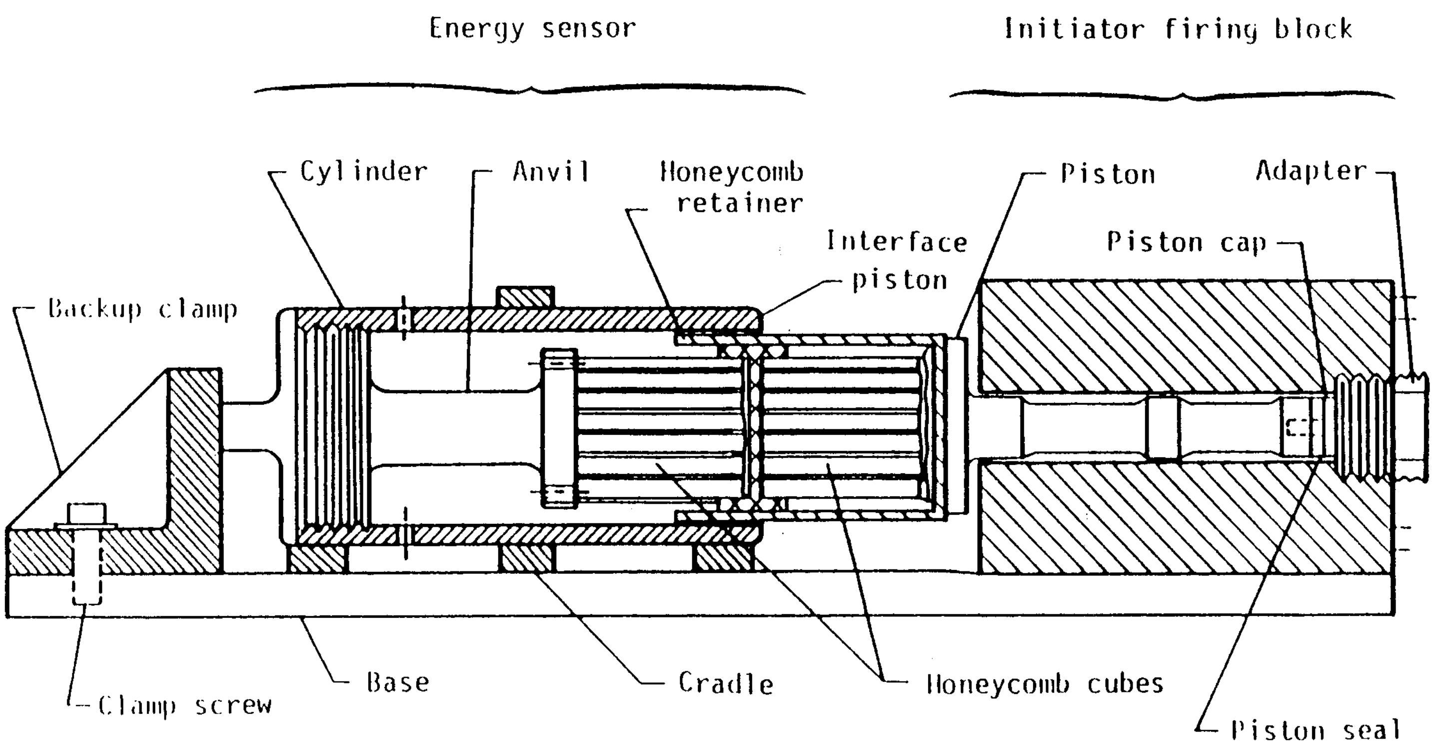
CLOSED BOMB FIRING AND MONITORING SYSTEM



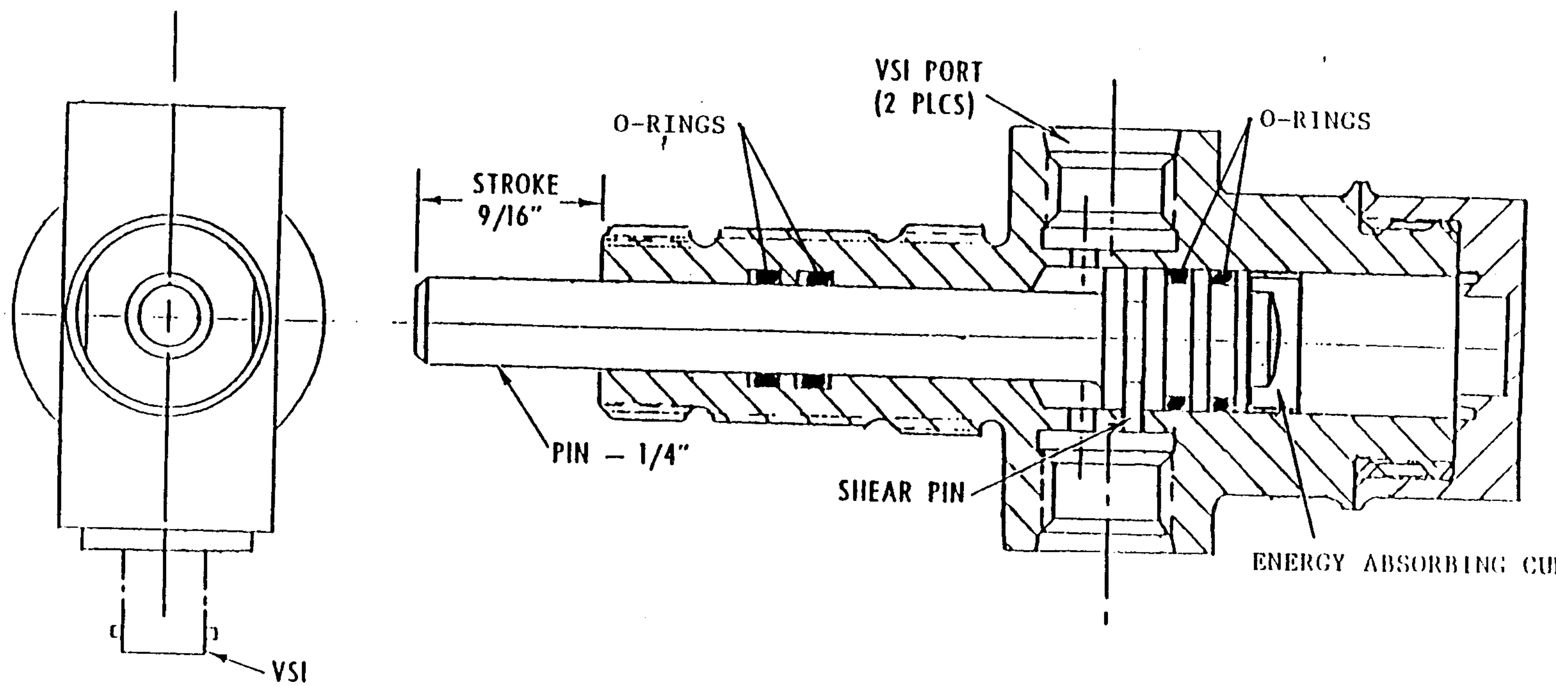
NASA LARC DYNAMIC TEST DEVICE



MCDONNELL ENERGY OUTPUT TEST FIXTURE



Viking PYRO OPERATED PIN PULLER — 1/4"



FEASIBILITY STUDY TEST RESULTS
AVERAGED OUTPUT

CARTRIDGE	CLOSED BOMB PSI/MS TO PK	DYN TEST DEV INCH-LBS	ENERGY SENSOR HONEYCOMB INCH-LBS	PIN PULL * .63/1.63 INCH-LBS
TEST METHODS DEMONSTRATION				
VSI	646/.13	366	466	121/152
VSI/BKNO3 EXT.	909/.31	542	652	
GAS GENERATING MATERIALS EVALUATION				
NSI	660/.23	346		
NSI/BKNO3 (25 %)	692/.33	418		
NSI/HI TEMP (25 %)	887/.36	543		
NSI/006 (25 %)	815/.35	502		
NSI/006 (50 %)	880/1.00	506		
NSI/006 (85 mg)	987	675	805	266/348
NSI/006 (90 mg, mod)		794	832	183/261
NSI/336 (55 mg)		517	505	
NSI/336 (85 mg, mod)		700	856	

* ENERGY DELIVERED AT 0.63 and 1.63-INCH STROKE

BEMENT/KARP/SCHIMMEL/MAGENOT
12/92

PROPOSED NSGG DELTA-QUALIFICATION

- 50 TO 70 UNITS FROM EACH SOURCE: HI SHEAR AND UPCO
- FOUR GROUPS AT 12 TO 17 UNITS TESTED:

TEMP CYCLING	MECHANICAL VIBRATION	MECHANICAL SHOCK	THERMAL SHOCK
1			
2	2		
3	3	3	
4	4	4	4

- TEST-FIRE, LAB AMBIENT, IN FOUR TEST METHODS
- COMPARE TO AS-RECEIVED PERFORMANCE

BEMENT/SCHIMMEL/KARP/MAGENOT
12/92

ATTACHMENT 16

JPL

PROGRAM SUPPORT STATUS

COMPUTER MODELING OF THE LOCKHEED/GALILEO LSB

COOPERATIVE RESEARCH PROJECT INVOLVING JPL APPLIED MECHANICS DIVISION AND NASA/MARSHALL SPACE FLIGHT CENTER (MSFC)

MILESTONES COMPLETED

- SOFTWARE INTERFACES (CODE PORTING FROM CRAY TO 80486 PC)
- PRELIMINARY 2-D MODEL (1/4 SYMMETRY)
- TASK PLAN DEVELOPED
- FUNDING TRANSFER FROM MSFC

PROBLEMS

- PRINCIPAL INVESTIGATOR

CURRENT STATUS

- FUNDING STILL AVAILABLE
- POSSIBLE REPLACEMENT SOUGHT

AMA 12/8/92

Jet Propulsion Laboratory
California Institute of Technology

4800 Oak Grove Drive
Pasadena, California 91109

(818) 354-4321

JPL

August 4, 1992

Mr. Joe B. Davis
NASA / Marshall Space Flight Center Code ED53
Huntsville, Alabama 35812

Subject: Task Plan for "Computer Modeling of the Lockheed/Galileo Separation System

Dear Mr. Davis,

Enclosed for your review are three copies of the subject task plan. This plan reflects previous discussions between yourself and Anthony Agajanian, of the Jet Propulsion Laboratory, including its potential application in the NASA Standard Linear Separation System development.

The funding to cover this task has been received at JPL and will be released to Anthony Agajanian upon receipt of your concurrence.

If you have any questions or require additional information regarding this task plan please contact Anthony Agajanian at (818) 354-9339. For contractual matters contact Mr. Rodney Gownes, JPL Contracts Management Office, at (818) 354-7903.

Sincerely,

J. A. Roberts
Manager, Assessment and Technology Review
Office of Engineering and Review

Concurrence: ______________________________ Date

J. B. Davis
Sponsoring Monitor
NASA/Marshall Space Flight Center

PROPOSAL FOR
COMPUTER MODELING
OF THE
LOCKHEED/GALILEO LINEAR SEPARATION SYSTEM
TO

NASA/Marshall Space Flight Center

Huntsville, Alabama

August 4, 1992

Prepared By

Anthony Aganian

A. M. Agajanian (Task Manager)
Member of Technical Staff
Mechanical Systems Development
Section

Steve Rivkin

S. Rivkin (Principal Investigator)
Member of Technical Staff
Mechanical Systems Development
Section

Approved By

B. Muirhead
Manager
Mechanical Systems Development
Section

W. S. Shipley
Assistant Laboratory Director
Office of Engineering and Review

JET PROPULSION LABORATORY
California Institute of Technology
Pasadena, California 91109

Program Title: A PROPOSAL FOR COMPUTER MODELING OF THE LOCKHEED/GALILEO LINEAR SEPARATION SYSTEM

Sponsoring Monitor: Joe B. Davis/Marshall Spaceflight Center (MSFC)

Principal Investigators: Steve Rivkin and John Kievit/Jet Propulsion Laboratory-California Institute of Technology

Prepared By: Anthony Agajanian/Jet Propulsion Laboratory-California Institute of Technology

Summary of Activities

We propose a cooperative research project involving the Applied Mechanics Division at the Jet Propulsion Laboratory and NASA/Marshall Space Flight Center. The goal is to develop a computer model of a linear separation system used to pyrotechnically separate large circumferencial interfaces between space vehicles and their payloads. Presently based on the Lockheed/Galileo configuration, the proposed computer model is estimated to greatly increase NASA's understanding of the pyro-mechanical functions involved with this and similar commercial designs and ultimately optimize reliability of the final system design.

The biggest problem associated with this pyro-mechanical system is understanding the detonating phenomena and its dynamic interactions with the other materials involved. Events of actuation are extremely fast and active elements are deeply embedded within the mechanical design that instrumenting tests becomes very complex and in most cases extremely expensive. As a result of this complexity most testing has been limited to a pass/fail criteria. We feel that this a very undesirable way of producing a high reliability system. It is the goal of the computer model to analyze the linear separation system in detail and unlock the mystery behind these systems to ultimately minimize hardware expenditures during evaluation and qualification and optimize system reliability.

For the past year, JPL investigators have been working on a model of the Lockheed/Galileo "SuperZip" design utilizing commercially available software packages and a USAF restricted usage code. Using the best capabilities of each package JPL investigators have developed the coarse-mesh model of the Lockheed/Galileo design. This design was chosen because of its flight proven success and the relatively large amount of test data. The Lockheed/ Galileo configuration is also a potential candidate for the NASA Standard Linear Separation System (SLSS) which has been implemented by the NASA Aerospace Pyrotechnically Actuated Systems (PAS) plan.

Activities of this proposal are two-fold. First will be the completion of the Lockheed/Galileo model, which we will refer to as the baseline and secondly to integrate empirical test data previously obtained from JPL to verify and evaluate the accuracy of the model. If time permits, data from Langley Research Center (LaRC) tests could also be used. Once Proven, the model could be used to complement future testing and to evaluate additional configurations sought by NASA.

Background

As with most commercially available linear separation system configurations, the baseline model consists of two interface rings that are held together by a series of precision/notched plates on both sides of the ring. An oval-shaped stainless steel tube, containing the Shielded Mild Detonating Cord (SMDC) imbedded in a silicone rubber matrix, is installed between the plates (Figure 1 /Shown in quarter-plane symmetry). When the SMDC is detonated, the force created by the detonation rapidly expands the tube and causes the notched plates to fracture thus separating the two structures (Figures 2 & 3). The detonation rate of this particular explosive mix is approximately 26,000 feet/second with common pressure fronts of 150,000 PSI. Because of these extraneous environments, dynamic instrumentation techniques such as Flash X-Ray and Smear Trace cameras can be implemented, however these techniques still require large quantities of test hardware with trial and error hypothesis.

We believe that the future in high reliability pyrotechnically actuated devices and systems is the analysis of their complex functioning through the use of computer modeling. Defining the separation mechanics of the subject systems requires novel engineering and specialized tools for understanding the interactions between detonating materials and mechanical structures. Mainly, determining functional performance effects of system variables such as explosive load (grain size) and position, structural properties of the notched plates and evaluating system tolerances to determine separation margin. We do not believe that the computer model is the only answer in designing reliable linear separation systems. However, it could be used as a powerful tool to substantiate experimental test data which can help to optimize design margins.

Strategy

At the present time, the necessary software interfaces have been completed and the two-dimentional (2-D) coarse-mesh model established. The strategy will be to further develop a high resolution 2-D model incorporating exact material constants and dimensions of the baseline and validate the operation with empirical test data previously obtained by JPL and LaRC. Assuming the proper material references are located, it is anticipated that this activity could be completed in less than six months.

Deliverables

Four months following the receipt of funding, a report will be presented to Mr. Davis covering the results of the 2-D modeling activity. Based on its progress at the end of the four month period, Mr. Davis can determine if the baseline model has appropriately fulfilled his expectations. It would be desirable to fund further research in this area if this effort shows promise.

Budget Justification

The JPL costs for the initial concept described in this proposal were covered under work for the Cassini flight program. As agreed, the $34K cost will cover a salary for one quarter of a work year and travel for NASA Pyrotechnic Steering Committee participation and/or interface meetings as necessary.

Double is AL-2024
AL-block is AL-6061

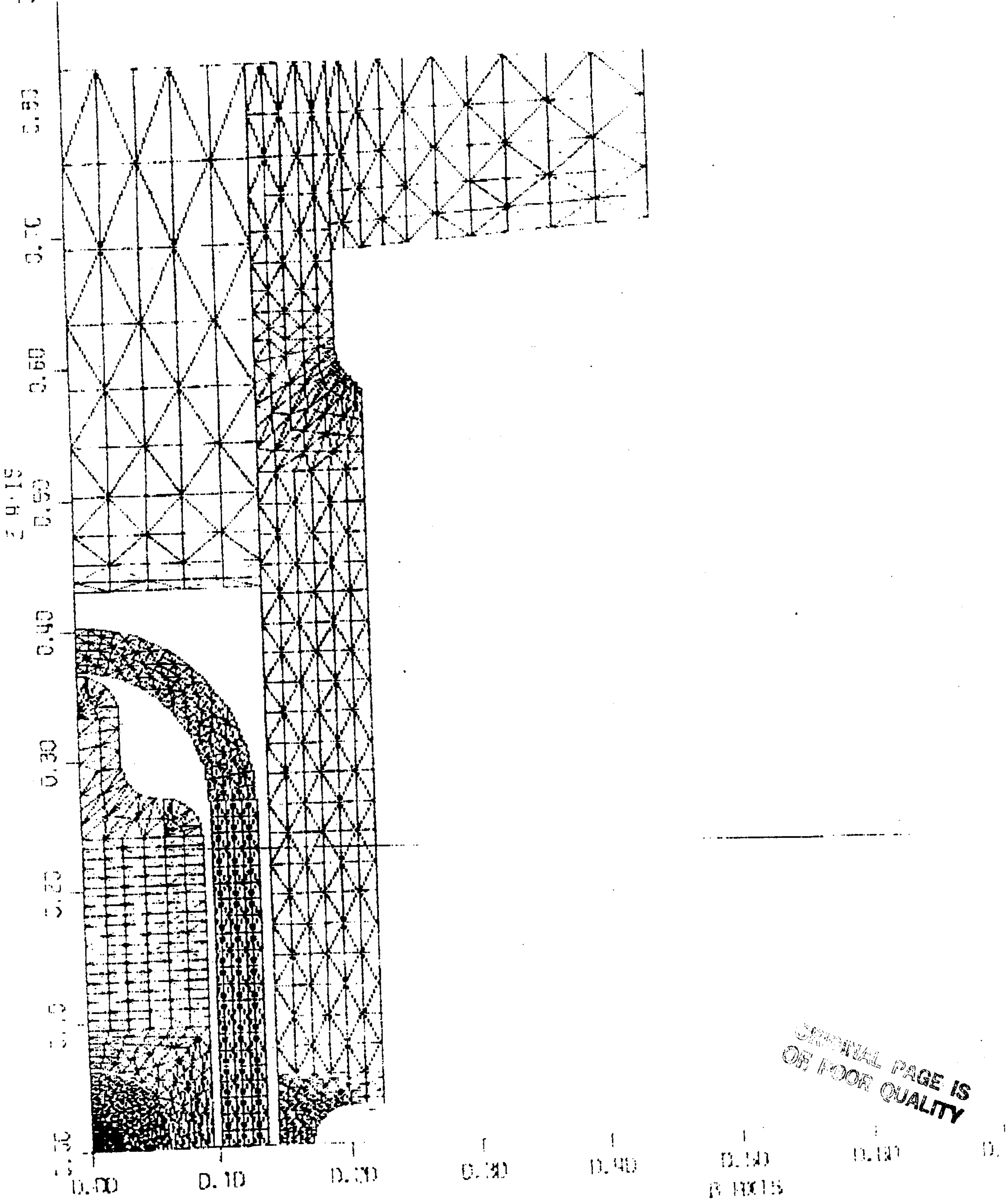


FIGURE 1

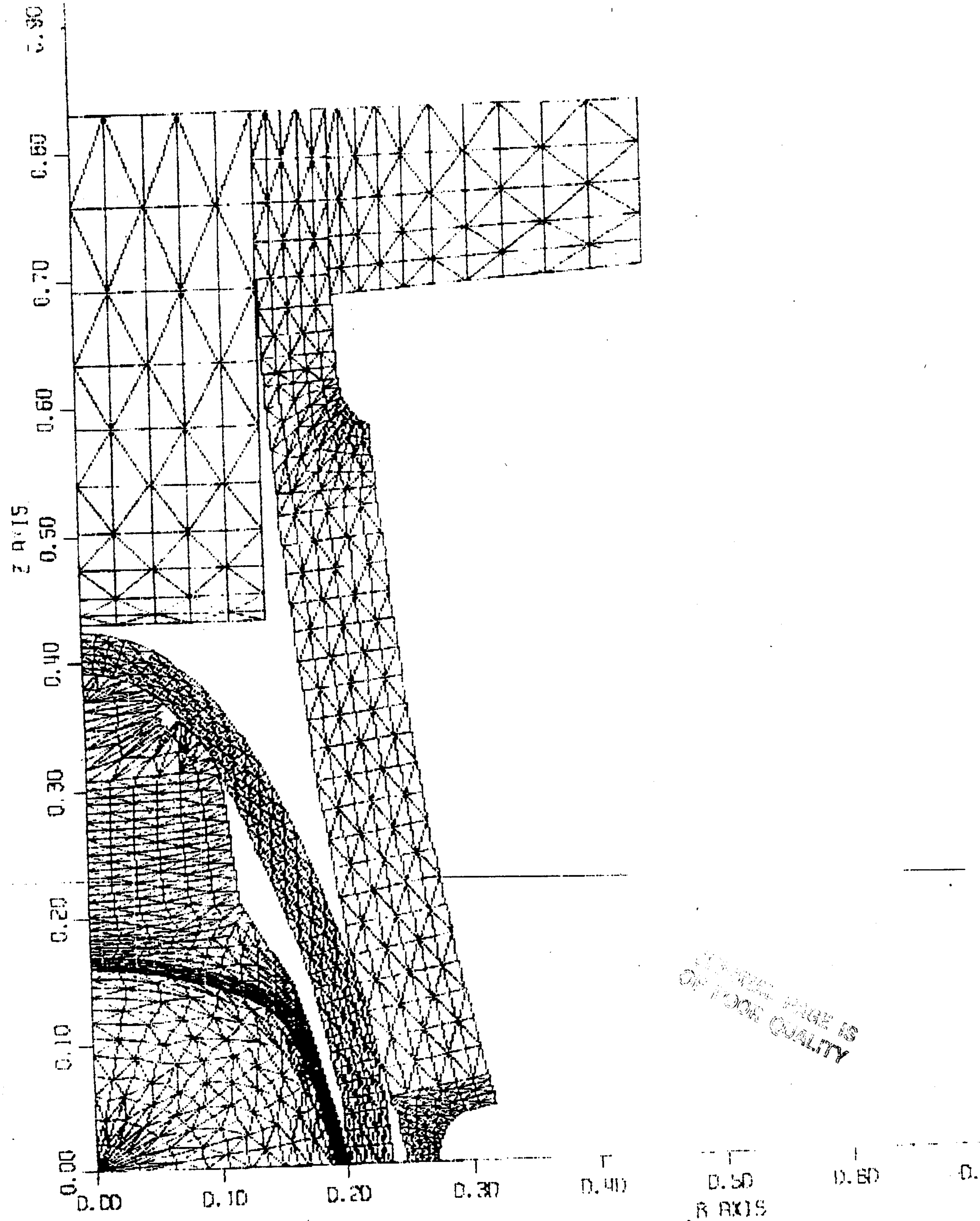

Z AXIS
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
0.00
0.10
0.20
0.30
0.40
0.50
0.60
R AXIS

FIGURE 2

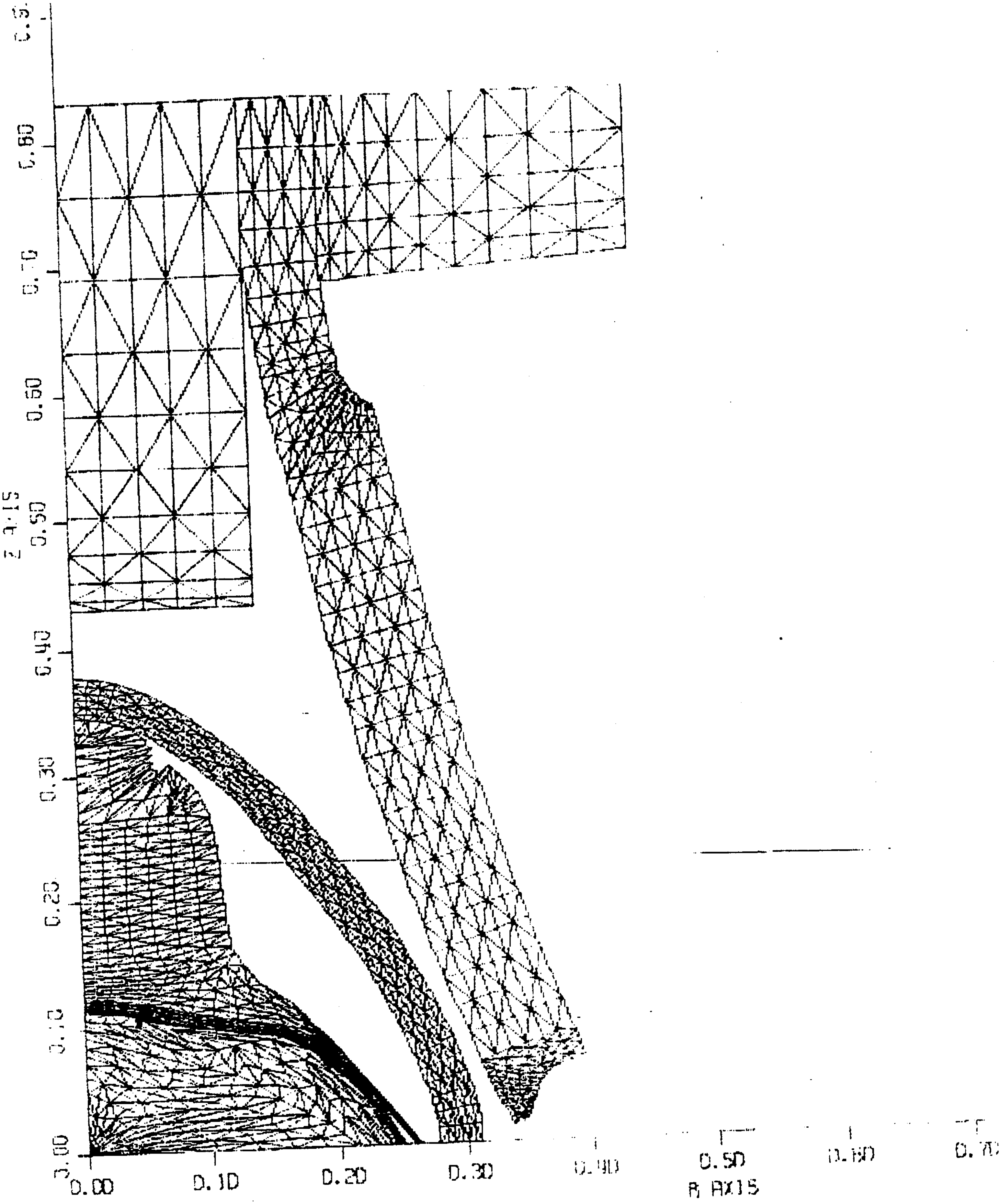


FIGURE 3

JPL Jet Propulsion Laboratory

ACHIEVEMENT: S. Rivkin

Modeling Effort
Division 35

CREATION DATE: Aug 6,1992

	ACTIVITY	1992				1993		
		FY92	FY93					
		SEP	OCT	NOV	DEC	JAN	FEB	MAR
1	Linear Separation Band Modeling							
2	Animation Software, Select and Order							
3	Calc. EOS, Materials Constants							
4	Huck Bolt Modeling							
5	Add Point Mass to Model							
6	Nominal GLL Super Zip Simulation							
7	Movie							
8	Nominal GLL Super Zip Simulation							
9	Hard Copy							
10	Effect of Changing Explosive Type							
11	to RDX, HNS Comp. B @ Nominal							
12	Load Size							
13	Effect of Changing Tube Materials							
14	on Nominal GLL Super Zip							
15	Effect of Changing Aluminum-Doubler							
16	Materials on Nominal GLL Super Zip							
17	JPL Experimental Results Comparison							
18	Final Report							
19	Travel							

ATTACHMENT 17

Johnson Space Center - Houston, Texas

LASER SAFE & ARM
LASER INITIATED DETONATOR
PROGRAM STATUS

Propulsion & Power Division

BARRY WITTSCHEN | 12/9/92

ACTIVITIES/TASKS

CONTRACT AWARDED (DEC. 1992)

RANGE SAFETY LAUNCH REQUIREMENTS

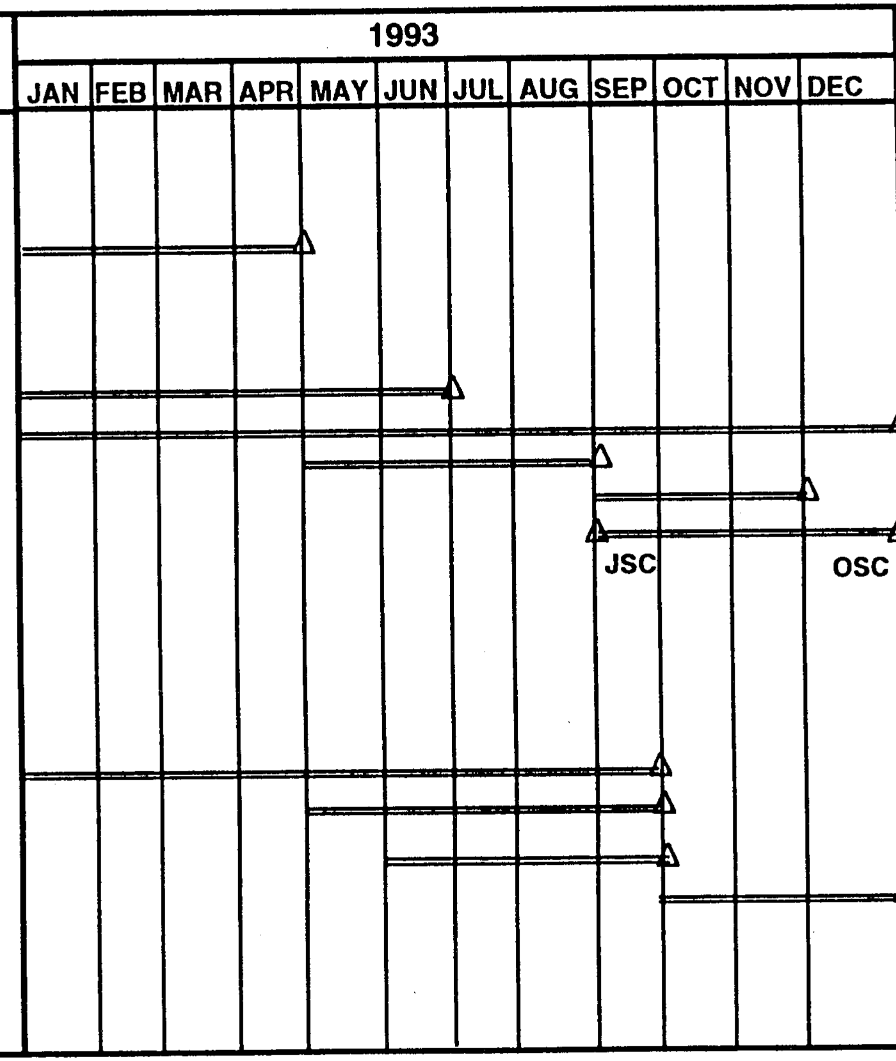
SYSTEM DEVELOPMENT

- DESIGN
- SYSTEM INTEGRATION
- MANUFACTURING
- QUALIFICATION/LAT TEST (EB)
- FLIGHT HARDWARE DELIVERY
  - JSC (3 LSA AND 150 LIDs)
  - OSC (10 LSA AND 10 LIDs)

NASA-JSC LSA/LID EVALUATION

- DEFINE TEST OBJECTIVES
- PREPARE TEST PLAN/PROCEDURES
- FACILITY SET-UP
- TESTING

PEGASUS FLIGHT DEMO (MARCH 1994)



ATTACHMENT 18

SERVICE EVALUATION OF SHUTTLE GROUND EGRESS PYROTECHNICS

OBJECTIVE - Determine the affect of flight service on this hardware to allow an extension of service life
- * Eliminate need to remove and replace system from some Orbiters
- * Considerable cost savings

APPROACH - Utilize the experience gained from the LaRC service evaluation of identical hardware removed from military aircraft (NASA TN 2143)

Bement/Schimmel/Hoffman 12/92

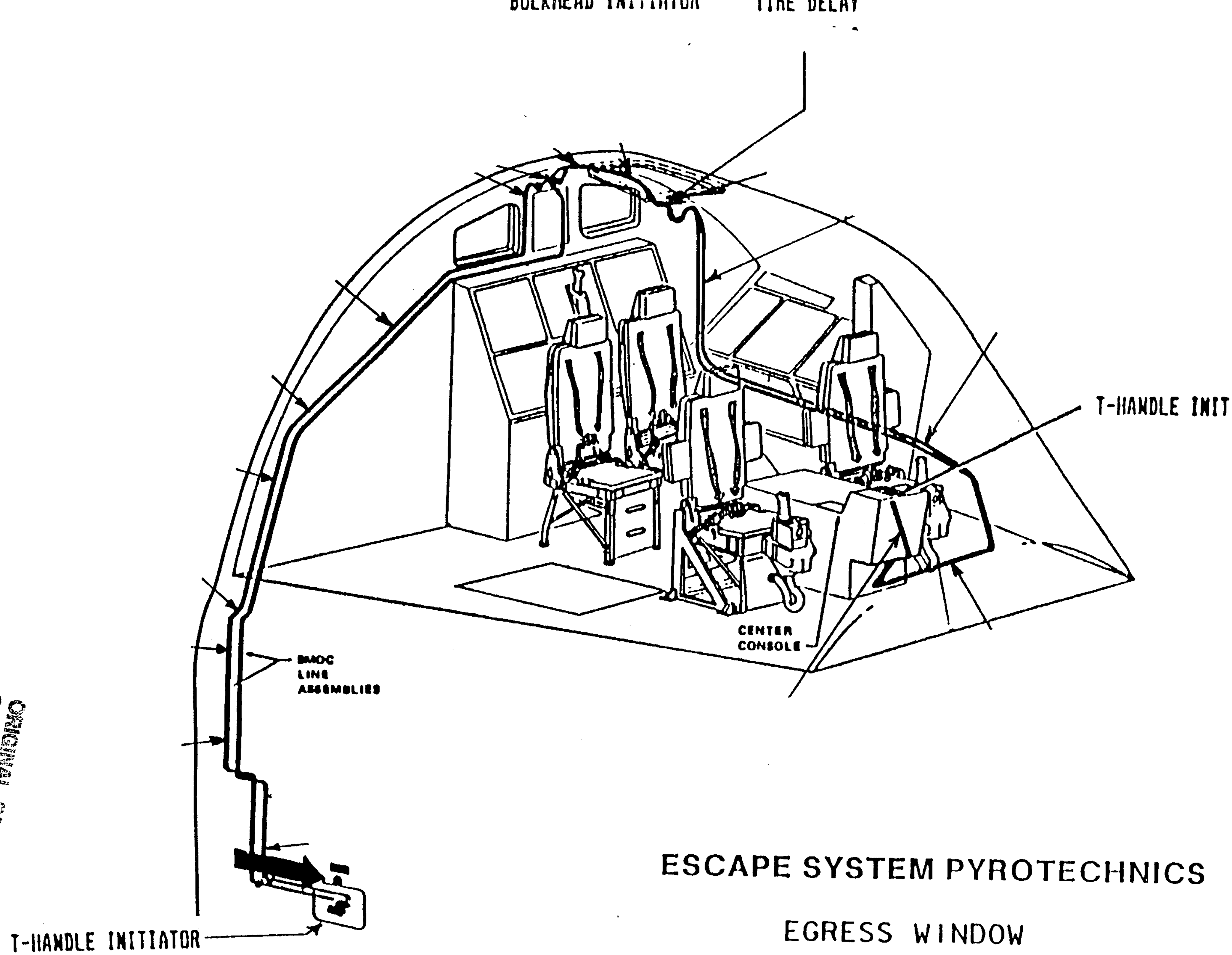
PROCEDURE

- Obtain one ship set of flight hardware (manuf 12/81-1/82, 10 years old)
    - * 24 rigid explosive transfer lines (SMDC)
    - * 12 flexible explosive transfer lines (FCDC)
    - * 4 through-bulkhead initiators (TBI)
    - * 1 window cutting assembly (WCA) inner/outer
- Obtain identical shelf hardware with no service (manuf 6/76, 15 years old)
    - * 10 SMDC
    - * 5 FCDC
- Control groups (half of sample of each device) functionally and chemically evaluated as received
- Other half exposed to a repeat thermal qualification and functionally and chemically evaluated

Bement/Schimmel/Hoffman 12/92

TEST TECHNIQUES

- Inspection: physical, x-ray in two planes
- Functional performance, velocities of:
    - * explosive propagation in the line
    - * end tip fragments (end and side) with witness plates
    - * end tip swell caps
- Chemical analyses on dissected samples of each component
    - * line
    - * transfer charge
    - * tip
    - * each charge in TBI



ESCAPE SYSTEM PYROTECHNICS

EGRESS WINDOW

Bement/Schimmel/Hoffman 12/92

RESULTS

- All hardware from control and repeat thermal qual groups meets performance for new components
- A 3 to 4% decrease occurred in velocity of explosive propagation, following repeat thermal qual (all lines)
- Test program allowed service extension on one Orbiter

Bement/Schimmel/Hoffman 12/92

NASA STANDARD LINEAR SEPARATION SYSTEM

- NASA needs competition
- Lockheed Super*Zip costs $1.25M per unit
- Technology not available to optimize performance for each mission
- Small diameter joints not available
- Requested by MSFC to evaluate ET joint
    * Qualified for Commercial Titan (vehicle abandoned)
    * Lower cost
    * Not qualified for NASA
    * Can't break into competition

Bement/Schimmel/Davis

APPROACH
- Conduct test program comparable to Super*Zip
- Obtained cost estimates from ET for test hardware

PROBLEM
- Insufficient funds to accomplish program

Bement/Schimmel 12/92

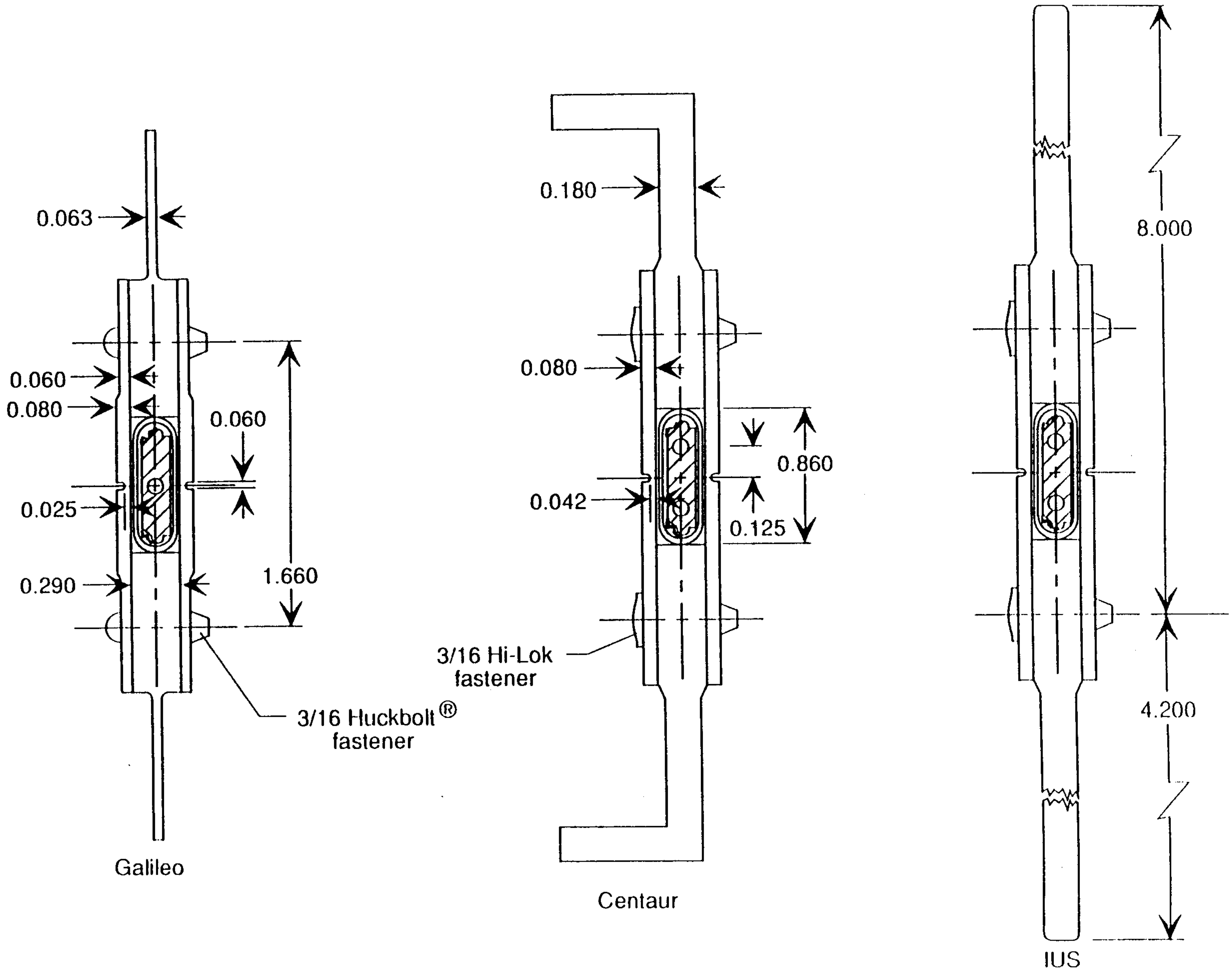
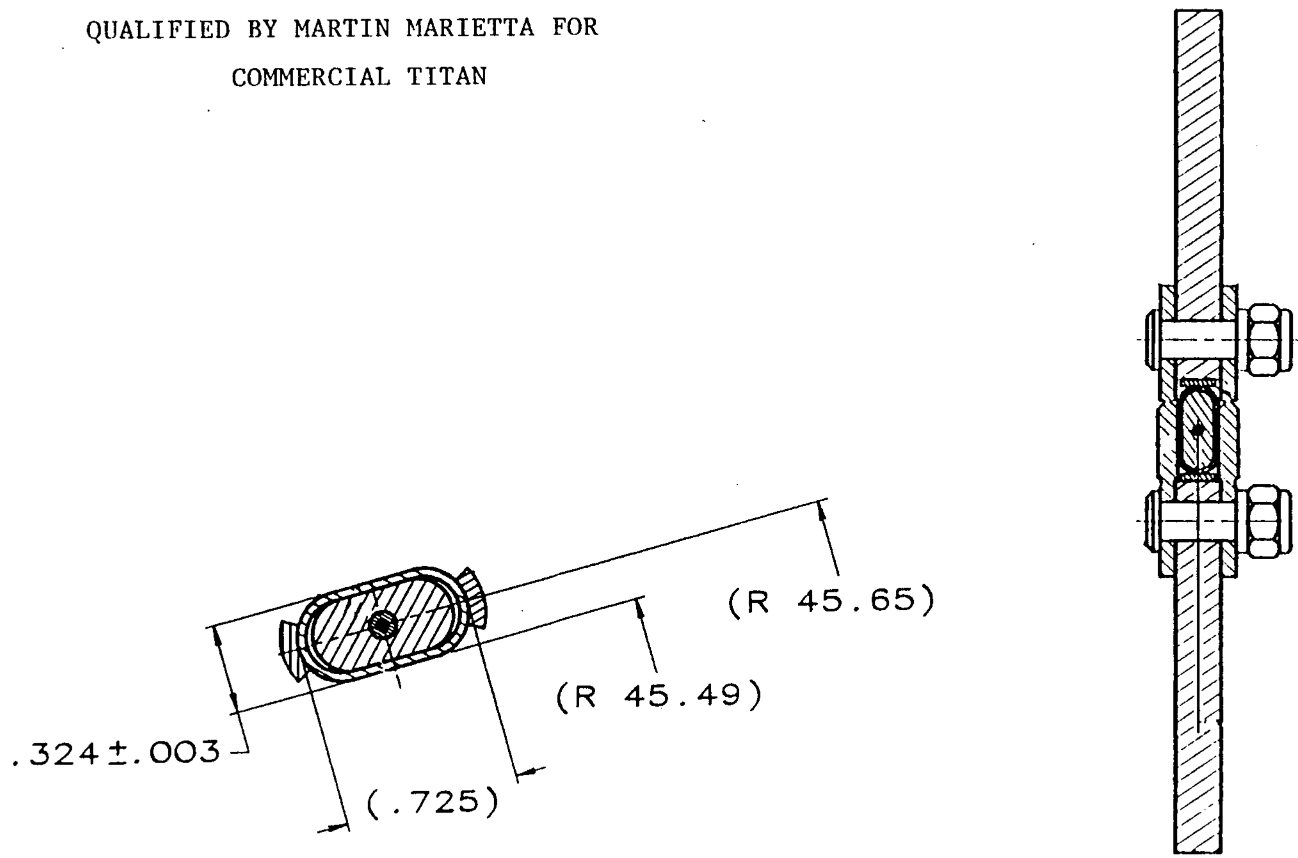


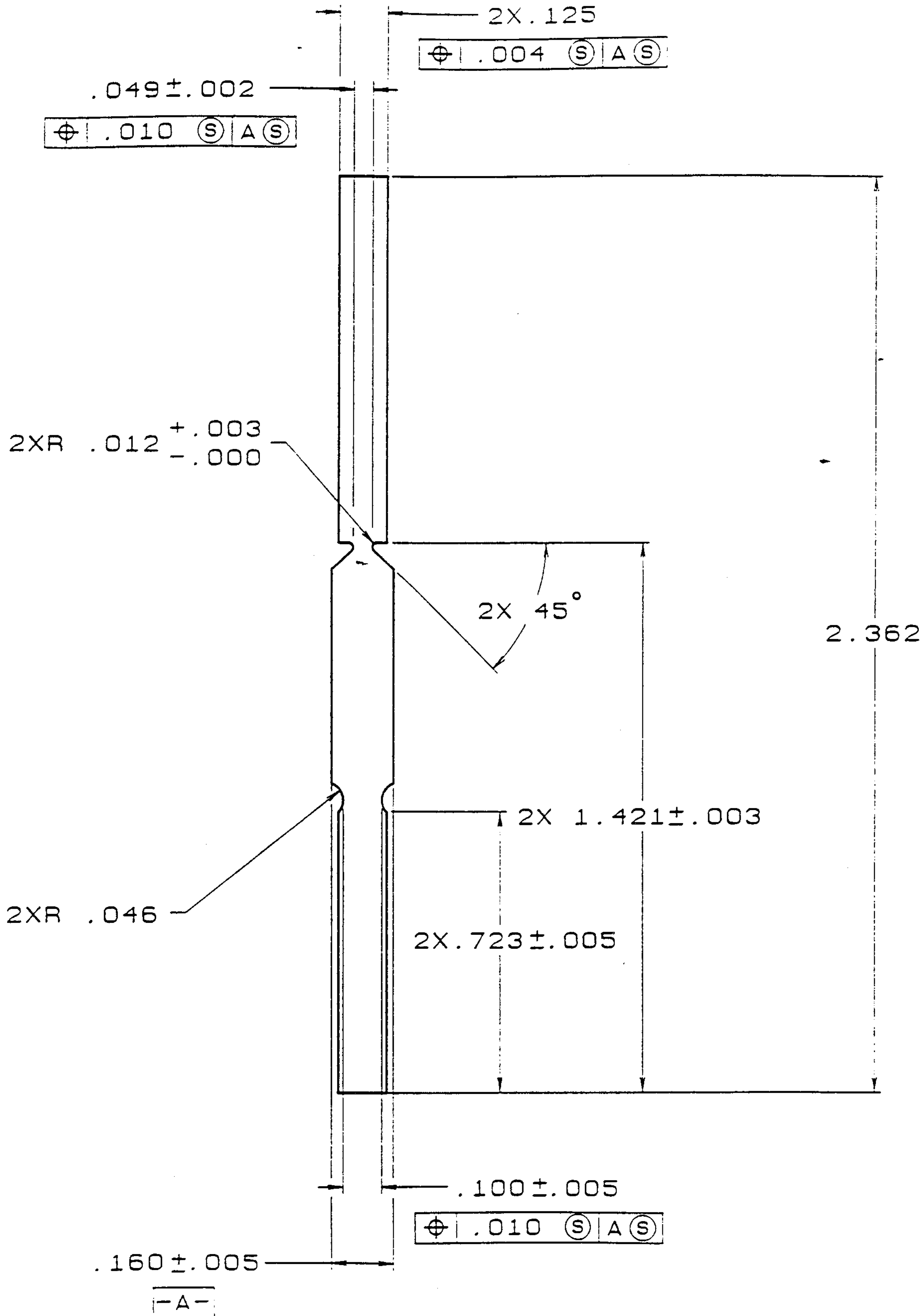
Figure 2. Cross sections of Galileo, Centaur, and IUS separation joints. ®Huckbolt: registered trademark of Huck Manufacturing Co.

ET SEPARATION JOINT

QUALIFIED BY MARTIN MARIETTA FOR

COMMERCIAL TITAN





2X .125
⌖ .004 Ⓢ A Ⓢ
.049±.002
⌖ .010 Ⓢ A Ⓢ
2XR .012 +.003 -.000
2X 45°
2.362
2X 1.421±.003
2XR .046
2X.723±.005
.100±.005
⌖ .010 Ⓢ A Ⓢ
.160±.005
-A-

ATTACHMENT 19

Pyrotechnic Modeling for the NSI Driven Pin Puller

Joseph M. Powers[1] and Keith A. Gonthier[2]

Department of Aerospace and Mechanical Engineering
University of Notre Dame
Notre Dame, Indiana 46556
(219) 239-5978
(219) 239-8341 (fax)
powers@neumann.ame.nd.edu

presented at the

7th NASA/DoD/DoE Aerospace Pyrotechnic Systems
Steering Committee Meeting

NASA Langley Research Center
Hampton, Virginia

December 9, 1992

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[1]Assistant Professor
[2]Graduate Assistant

Acknowledgements

Support

NASA-Lewis Research Center

NAG-1335

Dr. Robert M. Stubbs, Monitor

Discussions

Prof. P. Barry Butler
University of Iowa

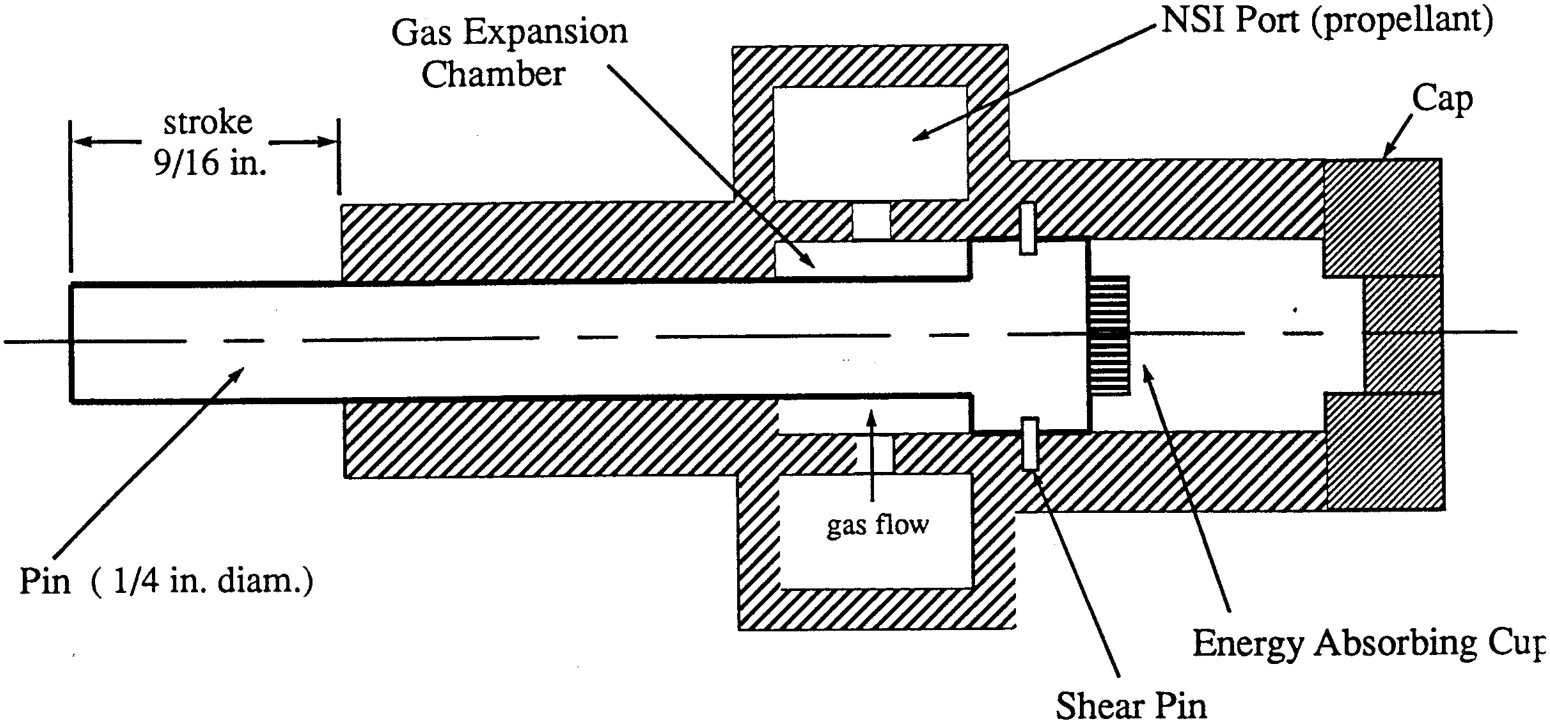
Mr. Laurence J. Bement
NASA-Langley Research Center

Work Completed

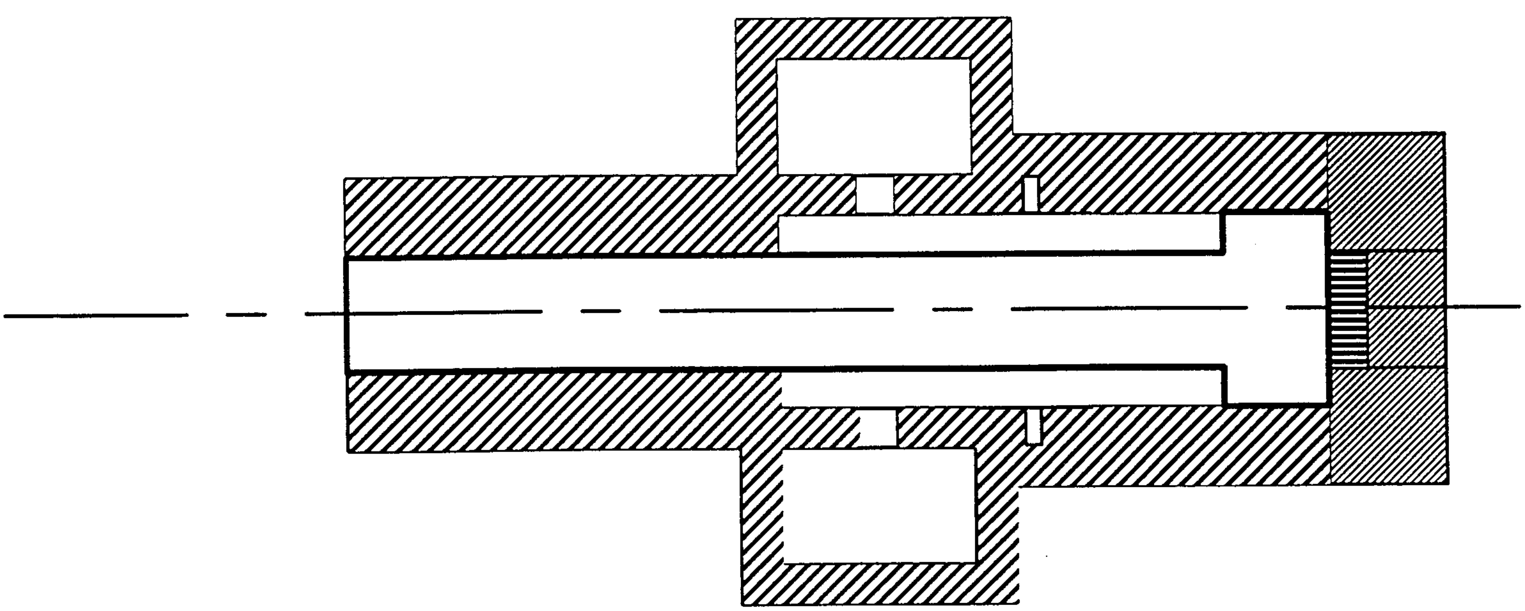
- Literature search conducted (2/92 – 4/92).
- Simple, first-principles model developed (5/92).
- Model presented at the NASA Aerospace Pyrotechnic Systems Workshop, June 9–10, 1992.
- Model prediction correlated with experimental data (6/92 – 8/92).
- Preliminary model and predictions presented in the NASA Lewis IFMD Seminar Series, September 15, 1992.
- Sensitivity analysis performed (9/92 – 11/92).

NSI Driven Pin Puller

(unretracted pin)



(retracted pin)



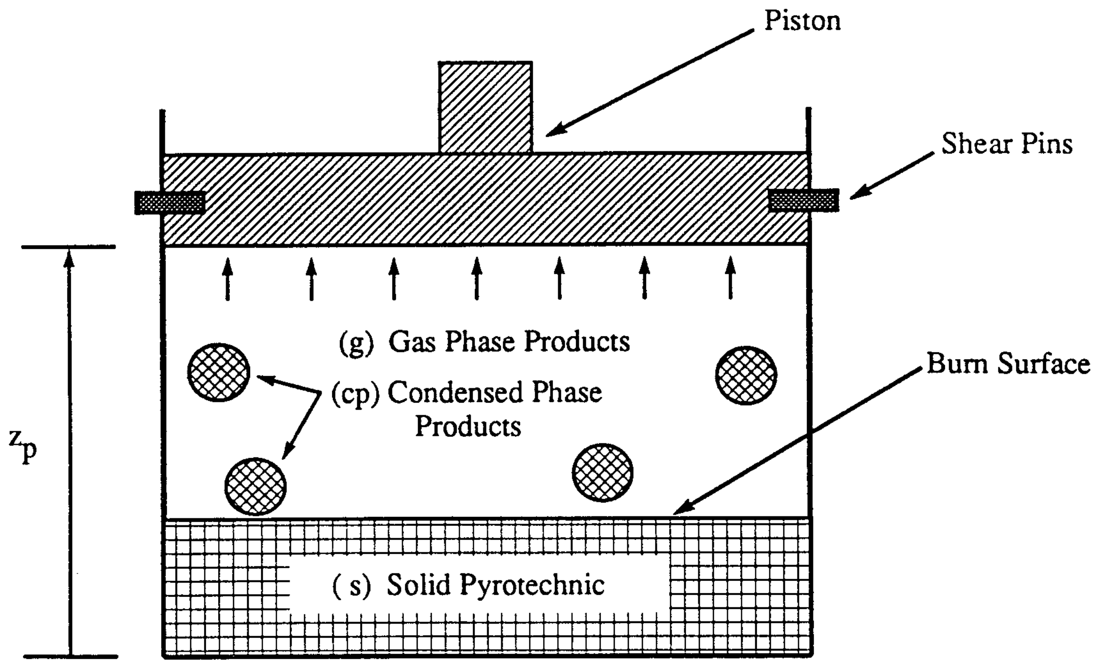
Engineering Problems

- Occurance of operational failures.
- Qualification only after many tests.
- Difficult to predict behavior of new formulations.
- Difficult to quantify effects of modifications.

Goals of This Study

- Perform detailed, *first-principles* investigation of pyrotechnic combustion.
- Develop a model to aid in the design of pyrotechnically actuated devices:
  - predict behavior of new formulations,
  - quantify effects of modifications,
  - identify important physical processes and how they effect the performance of the device.

Assumptions for the Preliminary Model



Chemical Reaction

$$\sum_{i=1}^{N_s} \nu_{s_i} X_{s_i} \longrightarrow \sum_{i=1}^{N_{cp}} \nu_{cp_i} X_{cp_i} + \sum_{i=1}^{N_g} \nu_{g_i} X_{g_i}$$

Key Assumptions:

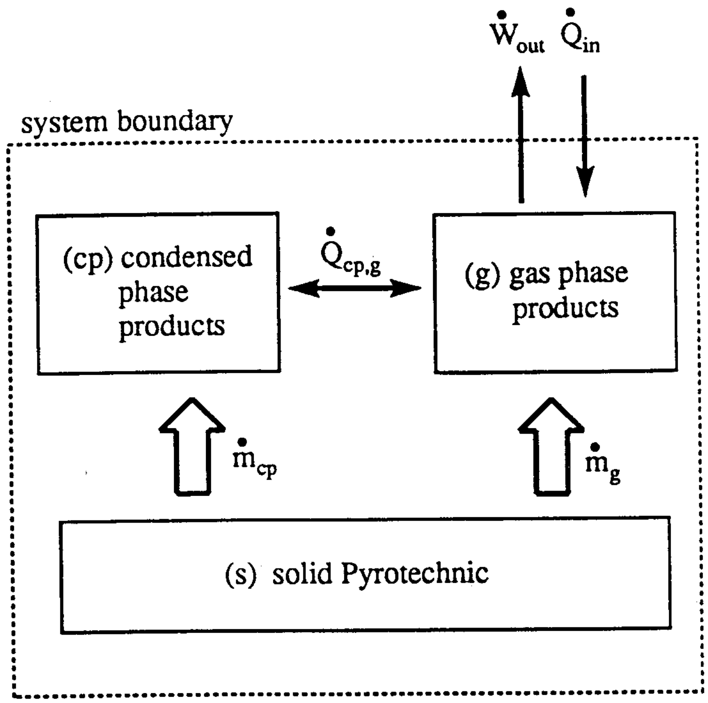
- Model total system as 3 subsystems.
- Well stirred reactor (time-dependent variables).
- Combustion products produced in ratios which minimize Gibbs free energy.
- Global kinetic burn rate estimated from solid propellant data.

Gets quick results

CET89 - Lewis Code

Assumptions cont'd.

Mass and Energy Exchange



- No mass exchange between total system and surroundings.
- Heat and work exchange between system and surroundings.
- Mass exchange from reactants to gas and condensed phase products.
- No work exchange between subsystems.
- Heat exchange between gas and condensed phase product subsystems.

Mass, Momentum, and Energy Principles

Mass Evolution Equations:

$$\frac{d}{dt}\left[\rho_s V_s\right] = -\rho_s A_p r,$$

$$\frac{d}{dt}\left[\rho_{cp} V_{cp}\right] = \eta_{cp}\rho_s A_p r,$$

$$\frac{d}{dt}\left[\rho_g V_g\right] = [1 - \eta_{cp}]\rho_s A_p r.$$

Energy Evolution Equations:

$$\frac{d}{dt}\left[\rho_s V_s e_s\right] = -\rho_s A_p e_s r,$$

$$\frac{d}{dt}\left[\rho_{cp} V_{cp} e_{cp}\right] = \eta_{cp}\rho_s A_p e_s r - \dot{Q}_{cp,g},$$

$$\frac{d}{dt}\left[\rho_g V_g e_g\right] = [1 - \eta_{cp}]\rho_s A_p e_s r + \dot{Q}_{cp,g} + \dot{Q}_{in} - \dot{W}_{out}.$$

Newton's Second Law:

$$m_p \frac{d^2 z_p}{dt^2} = F_p.$$

Geometrical and Constitutive Relations

A. Geometry

$$V = V_s + V_{cp} + V_g$$

$$z_p = \frac{V}{A_p}$$

B. Pyrotechnic Burn Rate

$$r = r(P_g, T_g) = a(T_g) + b(T_g)P_g^n$$

C. Thermal Equation of State

$$P_g = \rho_g R T_g,$$

where

$$R = \Re \sum_{i=1}^{N_g} \frac{Y_{g_i}}{M_{g_i}}, \qquad Y_{g_i} = \frac{\nu_{g_i} M_{g_i}}{\sum_{j=1}^{N_g} \nu_{g_j} M_{g_j}}$$

D. Caloric Equations of State

$$e_s(T_s) = \sum_{i=1}^{N_s} Y_{s_i} e_{s_i}(T_s)$$

$$e_{cp}(T_{cp}) = \sum_{i=1}^{N_{cp}} Y_{cp_i} e_{cp_i}(T_{cp})$$

$$e_g(T_g) = \sum_{i=1}^{N_g} Y_{g_i} e_{g_i}(T_g)$$

Geometrical and Constitutive Relations, cont'd.

E. Model for $\dot{Q}_{in}$:

$$\dot{Q}_{in} = \underbrace{hA_w\left[T_w - T_g\right]}_{convection} + \underbrace{\sigma A_w\left[\alpha T_w^4 - \epsilon T_g^4\right]}_{radiation},$$

F. Model for $\dot{W}_{out}$:

$$\dot{W}_{out} = P_g \frac{dV}{dt}.$$

G. Model for F_p:

$$F_p = \begin{cases} 0 & \text{if } P_g A_p < F_{crit} \\ P_g A_p & \text{if } P_g A_p \geq F_{crit}, \end{cases}$$

- F_{crit}, constant critical force necessary for shear pin failure.

H. Model for $\dot{Q}_{cp,g}$:

$$\dot{Q}_{cp,g} = h_{cp,g}\left[T_{cp} - T_g\right].$$

- $h_{cp,g}$, heat transfer parameter.

Mathematical Reductions

Goal:

- To perform intermediate operations leading to a refined final model:
  - six O.D.E.'s for V, V_s, V_{cp}, T_{cp}, T_g, and $\dot{V}$
  - all other variables expressed as a function of these six variables.
- Final model suitable for numerical integration.

Step I. Determination of ρ_g.

- Add together *mass evolution equations*:

$$\frac{d}{dt}\left[\rho_s V_s + \rho_{cp} V_{cp} + \rho_g V_g\right] = 0.$$

- Integrate, apply intital conditions, and solve for ρ_g:

$$\rho_g(V, V_s, V_{cp}) = \frac{\rho_s V_{so} + \rho_{cp} V_{cpo} + \rho_{go} V_{go} - \rho_s V_s - \rho_{cp} V_{cp}}{V - V_s - V_{cp}}.$$

Mathematical Reductions, cont'd.

Step II. Expression for mixture energy evolution.

- Add together *energy evolution equations*:

$$\frac{d}{dt}\left[\rho_s V_s e_s + \rho_{cp} V_{cp} e_{cp} + \rho_g V_g e_g\right] = \dot{Q}_{in} - \dot{W}_{out}.$$

  - Note: this expression is *not* explicitly used in the analysis.
  - For special case $\dot{Q}_{in} = \dot{W}_{out} = 0$, can integrate:

$$\rho_s V_s e_s + \rho_{cp} V_{cp} e_{cp} + \rho_g V_g e_g = \rho_s V_{so} e_{so} + \rho_{cp} V_{cpo} e_{cpo} + \rho_{go} V_{go} e_{go}.$$

  - Can use algebraic relation to evaluate code performance.

Step III. Determination of P_g.

- Use ρ_g from Step I and *thermal equation of state* to obtain:

$$P_g(V, V_s, V_{cp}, T_g) = \rho_g(V, V_s, V_{cp}) R T_g.$$

Mathematical Reductions, cont'd.

Step IV. Determination of r and F_p.

- Using P_g from Step III, can obtain:

$$r = r(V, V_s, V_{cp}, T_g) = a(T_g) + b(T_g)P_g^n(V, V_s, V_{cp}, T_g),$$

$$F_p = F_p(V, V_s, V_{cp}, T_g).$$

Step V. Simplify remaining differential mass equations.

- Since ρ_s and ρ_{cp} are constants:

$$\frac{dV_s}{dt} = -A_p r(V, V_s, V_{cp}, T_g), \tag{1}$$

$$\frac{dV_{cp}}{dt} = \eta_{cp}\left[\frac{\rho_s}{\rho_{cp}}\right] A_p r(V, V_s, V_{cp}, T_g). \tag{2}$$

Mathematical Reductions, cont'd.

Step VI. Simplification of energy equations.

- Consider energy evolution equation for *solid pyrotechnic*:

$$\frac{d}{dt}\left[\rho_s V_s e_s\right] = -\rho_s A_p e_s r,$$

  – subtract the following from this equation:

$$\left[\frac{d}{dt}\left[\rho_s V_s\right] = -\rho_s A_p r\right] e_s,$$

  – obtain:

$$\frac{de_s}{dt} = 0, \qquad \Longrightarrow \qquad e_s = e_{so}.$$

- Consider energy evolution equation for *condensed phase products*:

$$\frac{d}{dt}\left[\rho_{cp} V_{cp} e_{cp}\right] = \eta_{cp}\rho_s A_p e_s r - \dot{Q}_{cp,g},$$

  – subtract the following:

$$\left[\frac{d}{dt}\left[\rho_{cp} V_{cp}\right] = \eta_{cp}\rho_s A_p r\right] e_{cp},$$

  – obtain:

$$\rho_{cp} V_{cp}\frac{de_{cp}}{dt} = \eta_{cp}\rho_s A_p r(V, V_s, V_{cp}, T_g)[e_{so} - e_{cp}(T_{cp})] - \dot{Q}_{cp,g}(T_{cp}, T_g),$$

Mathematical Reductions, cont'd.

– using caloric equation of state $e_{cp}(T_{cp})$:

$$\frac{dT_{cp}}{dt} = \frac{\eta_{cp}\rho_s A_p r(V, V_s, V_{cp}, T_g)[e_{so} - e_{cp}] - \dot{Q}_{cp,g}(T_{cp}, T_g)}{\rho_{cp} c_{cp}(T_{cp}) V_{cp}}. \quad (3)$$

- Consider energy evolution equation for *gas phase products*:

$$\frac{d}{dt}[\rho_g V_g e_g] = [1 - \eta_{cp}]\rho_s A_p e_s r + \dot{Q}_{cp,g} + \dot{Q}_{in} - \dot{W}_{out},$$

– subtract the following:

$$\left[\frac{d}{dt}[\rho_g V_g] = [1 - \eta_{cp}]\rho_s A_p r\right] e_g,$$

– obtain:

$$\rho_g V_g \frac{de_g}{dt} = [1 - \eta_{cp}]\rho_s A_p r[e_{so} - e_g] + \dot{Q}_{in} - \dot{W}_{out},$$

– using caloric equation of state $e_g(T_g)$:

$$\frac{dT_g}{dt} = \frac{[1 - \eta_{cp}]\rho_s A_p r(V, V_s, V_{cp}, T_g)\,[e_{so} - e_g(T_g)] + \dot{Q}_{cp,g}(T_{cp}, T_g)}{\rho_g(V, V_s, V_{cp}) c_{vg}(T_g)[V - V_s - V_{cp}]}$$

$$+ \quad \frac{\dot{Q}_{in}(T_g) - P_g(V, V_s, V_{cp}, T_g)\dot{V}}{\rho_g(V, V_s, V_{cp}) c_{vg}(T_g)[V - V_s - V_{cp}]}, \quad (4)$$

Mathematical Reductions, cont'd.

Step VII. Newton's second law governing piston motion.

- Split 2^{nd} order O.D.E. into two 1^{st} order O.D.E.'s:

$$\frac{dV}{dt} = \dot{V}, \tag{5}$$

$$\frac{d\dot{V}}{dt} = \frac{F_p(V, V_s, V_{cp}, T_g)A_p}{m_p}. \tag{6}$$

Final Form of Preliminary Model

Governing O.D.E.'s:

$$\frac{dV}{dt} = \dot{V},$$

$$\frac{dV_s}{dt} = -A_p r(V, V_s, V_{cp}, T_g),$$

$$\frac{dV_{cp}}{dt} = \eta_{cp} \left[\frac{\rho_s}{\rho_{cp}}\right] A_p r(V, V_s, V_{cp}, T_g),$$

$$\frac{dT_{cp}}{dt} = \frac{\eta_{cp}\rho_s A_p r(V, V_s, V_{cp}, T_g)[e_{so} - e_{cp}(T_{cp})] - \dot{Q}_{cp,g}(T_{cp}, T_g)}{\rho_{cp} c_{cp}(T_{cp}) V_{cp}},$$

$$\begin{aligned}\frac{dT_g}{dt} &= \frac{[1-\eta_{cp}]\rho_s A_p r(V, V_s, V_{cp}, T_g)\,[e_{so} - e_g(T_g)] + \dot{Q}_{cp,g}(T_{cp}, T_g)}{\rho_g(V, V_s, V_{cp}) c_{vg}(T_g)[V - V_s - V_{cp}]} \\ &+ \frac{\dot{Q}_{in}(T_g) - P_g(V, V_s, V_{cp}, T_g)\dot{V}}{\rho_g(V, V_s, V_{cp}) c_{vg}(T_g)[V - V_s - V_{cp}]},\end{aligned}$$

$$\frac{d\dot{V}}{dt} = \frac{F_p(V, V_s, V_{cp}, T_g) A_p}{m_p}.$$

Initial Conditions:

$$V(t=0) = V_o, \qquad V_s(t=0) = V_{so}, \qquad V_{cp}(t=0) = V_{cpo},$$

$$T_{cp}(t=0) = T_s, \qquad T_g(t=0) = T_s, \qquad \dot{V}(t=0) = 0.$$

Initial Results

- pressure-time predictions for a 10 cm^3 closed bomb combustion of 114 mg of $Zr/KClO_4$,
- pressure-time predictions and piston energy calculations for typical operation of NSI driven pin puller,
- parametric sensitivity analysis for burn rate and heat transfer parameters.

Balanced Stoichiometric Equation:

$$\begin{aligned} 3.6162Zr(s) + 2.6849KClO_4(s) \longrightarrow\ & 3.2354ZrO_2(l) + 1.9712O(g) \\ & +1.6988KCl(g) + 0.9766Cl(g) \\ & +0.9041K(g) + 0.7454O_2(g) \\ & +0.3407ZrO_2(g) + 0.0790KO(g) \\ & +0.0401ZrO(g) + 0.0065ClO(g) \\ & +0.0009K_2ClO_2(g) + 0.0006Cl_2(g) \\ & +0.0006K_2(g). \end{aligned}$$

NSI Pyrotechnic Composition:

- 114 mg of a $Zr/KClO_4$ mixture:
  - 53.6 mg of $Zr(s)$,
  - 60.4 mg of $KClO_4$.

Closed Bomb Combustion (10 cm^3)

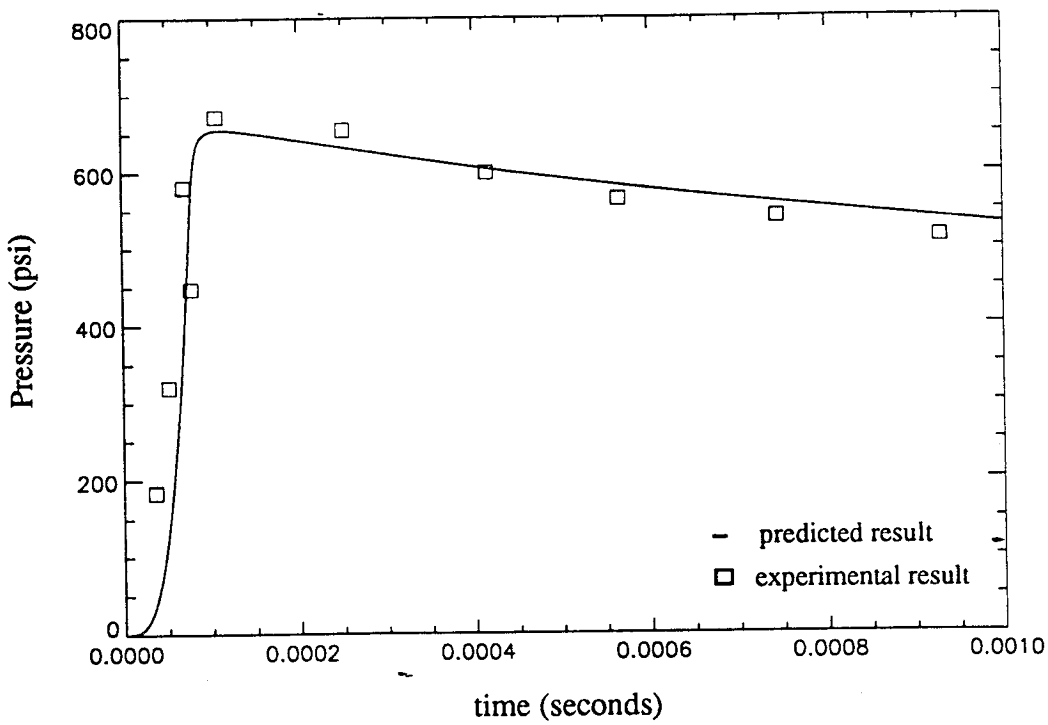
- Initial Conditions:

initial condition	*value*
V_o	10.0 cm^3
V_{so}	0.038 cm^3
V_{cpo}	5.10×10^{-7} cm^3
T_{cpo}	288.0 K
T_{go}	288.0 K
$\dot{V}$	0.0 cm^3/sec

- Parameters:

parameter	*value*
burn area, A_p	2.0 cm^2
pyrotechnic density, ρ_s	3.0 g/cm^3
temperature of pyrotechnic, T_s	288.0 K
condensed phase density, ρ_{cp}	1.51 g/cm^3
convective heat transfer coefficient, h	1.25×10^5 $g/sec^3/K$
emissivity of the gas, ϵ	0.60
absorptivity of the vessel's walls, α	0.60
heat transfer parameter, $h_{cp,g}$	12.0×10^9 $gcm^2/sec^3/K$
burn rate parameter, a	0.00 $dynes^{-0.69}cm/sec$
burn rate parameter, b	0.004 $dynes^{-0.69}cm/sec$
burn index, n	0.69

Closed Bomb Combustion, cont'd.



- NASA specifications: firing an NSI containing 114 mg of $Zr/KClO_4$ mixture into a 10 cm^3 volume shall produce a peak pressure of 650$\pm$125 psi within 5 $msec$,

- model predicts the correct trends.

NSI Driven Pinpuller Results

- Initial Conditions:

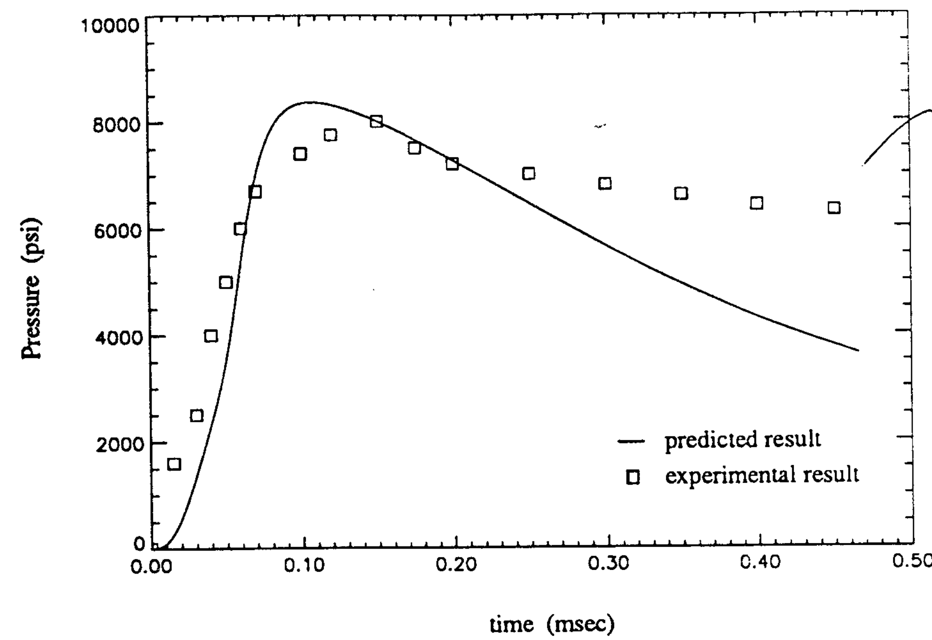
initial condition	*value*
V_o	$0.824\ cm^3$
V_{so}	$0.038\ cm^3$
V_{cpo}	$3.40\times10^{-6}\ cm^3$
T_{cpo}	$288.0\ K$
T_{go}	$288.0\ K$
$\dot{V}$	$0.0\ cm^3/sec$

- Parameters:

parameter	*value*
burn area, A_p	$0.634\ cm^2$
pyrotechnic density, ρ_s	$3.0\ g/cm^3$
pyrotechnic temperature, T_s	$288.0\ K$
condensed phase density, ρ_{cp}	$1.51\ g/cm^3$
convective heat transfer coefficient, h	$1.25\times10^5\ g/sec^3/K$
emissivity of the gas, ϵ	0.60
absorptivity of the vessel's walls, α	0.60
heat transfer parameter, $h_{cp,g}$	$12.0\times10^9\ gcm^2/sec^3/K$
critical shearing force, F_{crit}	$3.56\times10^7\ dynes\ (80\ lbf)$
burn rate parameter, a	$0.00\ dynes^{-0.69}cm/sec$
burn rate parameter, b	$0.004\ dynes^{-0.69}cm/sec$
burn index, n	0.69

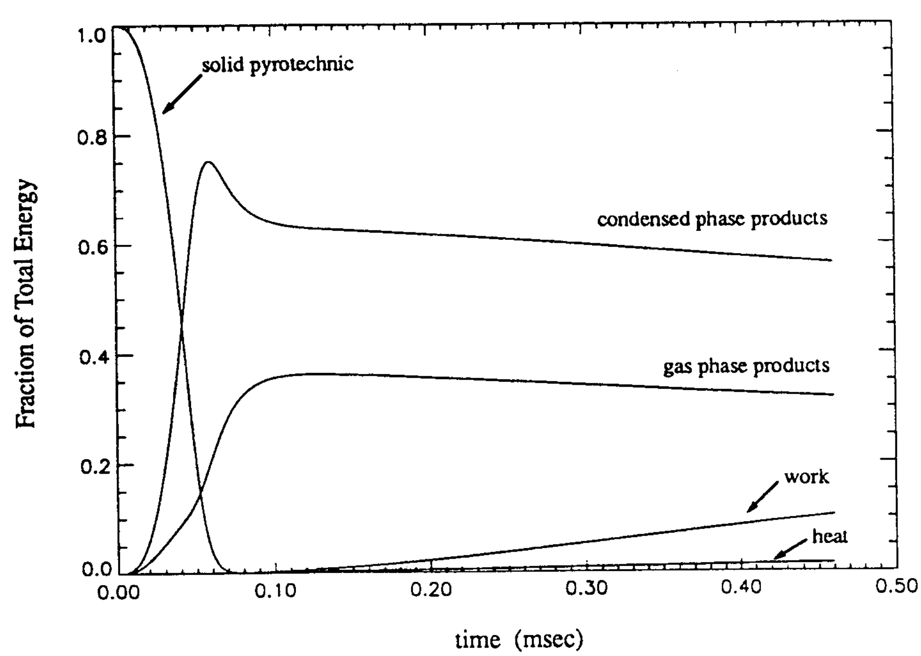
NSI Driven Pinpuller Results, cont'd.

- Pressure – time prediction:



Model lacks a [illegible]

- Energy Partitioning:



- main features are predicted by model:
  - maximum pressure,
  - time scale of events.

Parametric Sensitivity Study

Problems:

- the model equations contain several unknown parameters,
- parameters must be selectively chosen from best available data.

Goals:

- quantify the sensitivity of the model to changes in the parameters,
- reduce the amount of detailed empirical information needed to determine parameters.

Methodology:

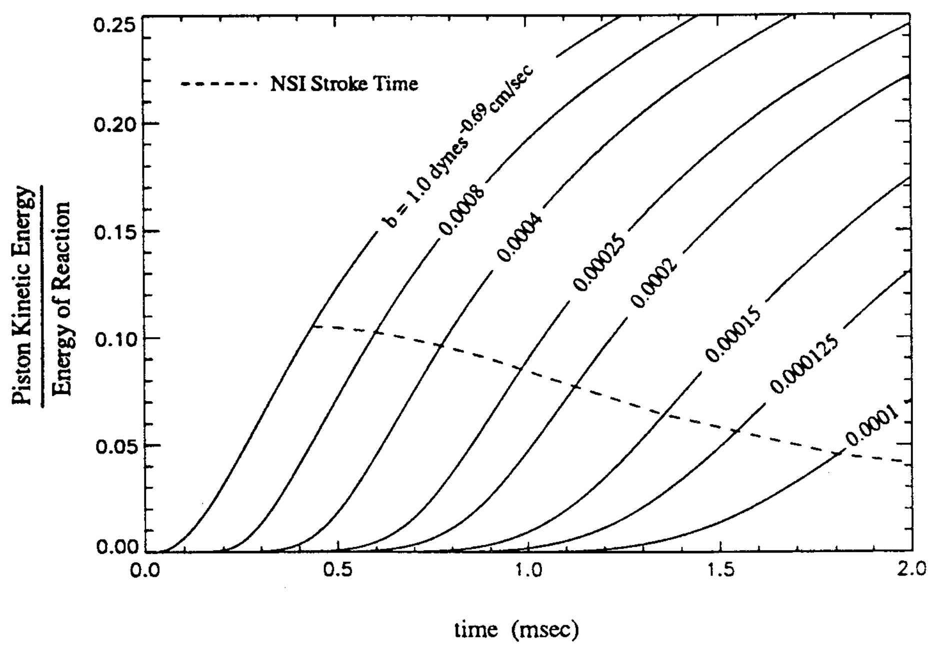
- use previous solution of pin puller simulation as *base solution*,
- independently vary each parameter and note corresponding change in kinetic energy of the pin.

Burn Rate Sensitivity Study

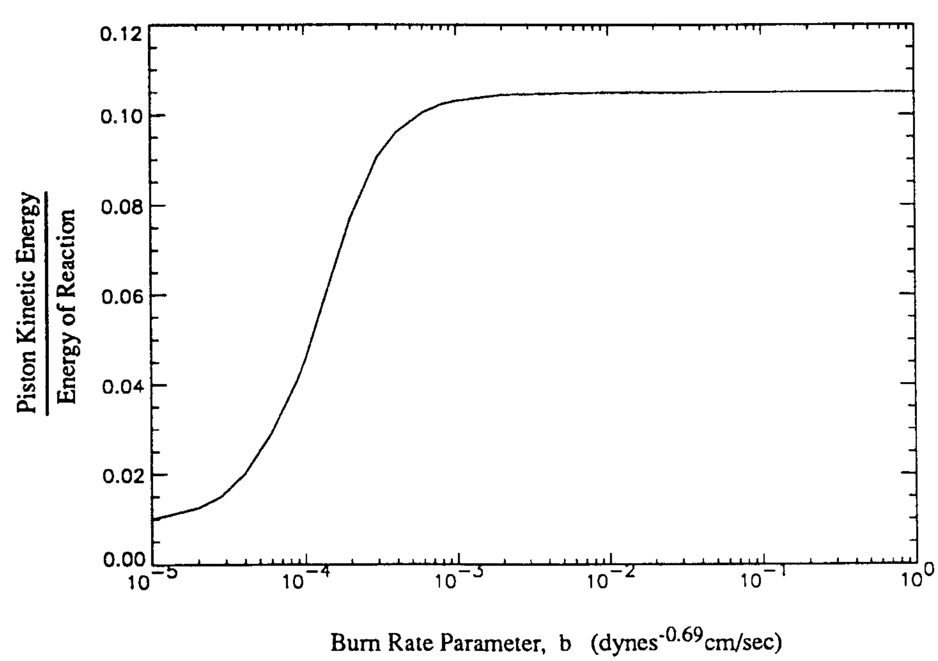
$$r = bP^n$$

1. Variations in b.

- kinetic energy – time curve



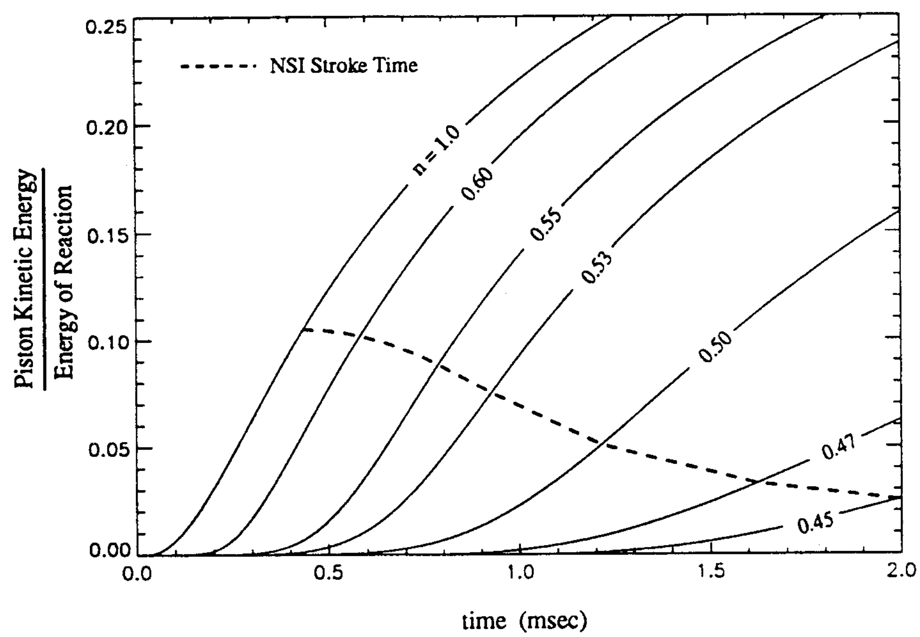
- kinetic energy at completion of the stroke



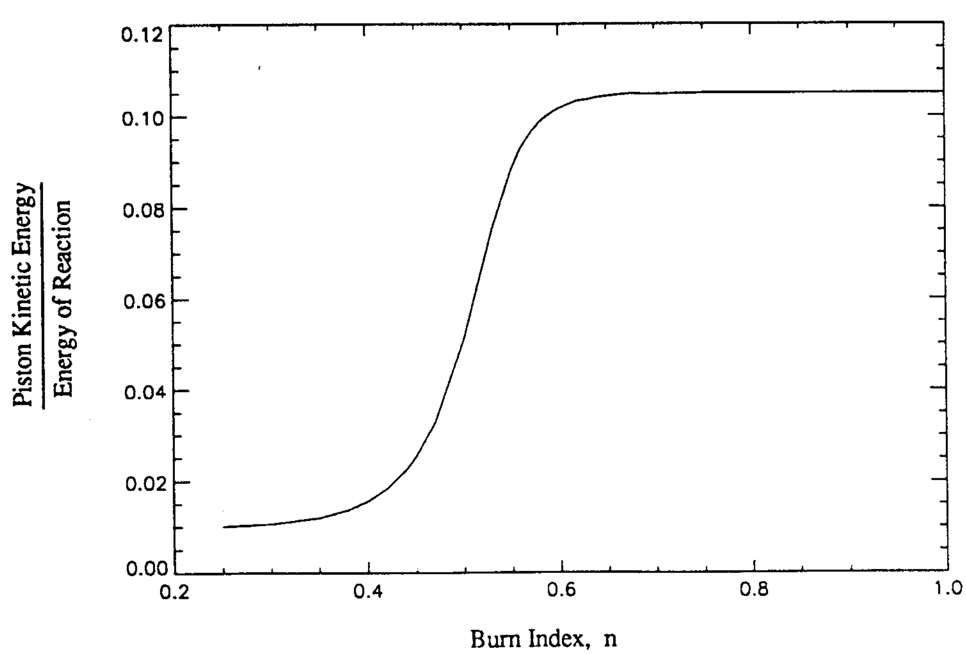
Burn Rate Study, cont'd

2. Variations in n.

- kinetic energy – time curve



- kinetic energy at completion of the stroke

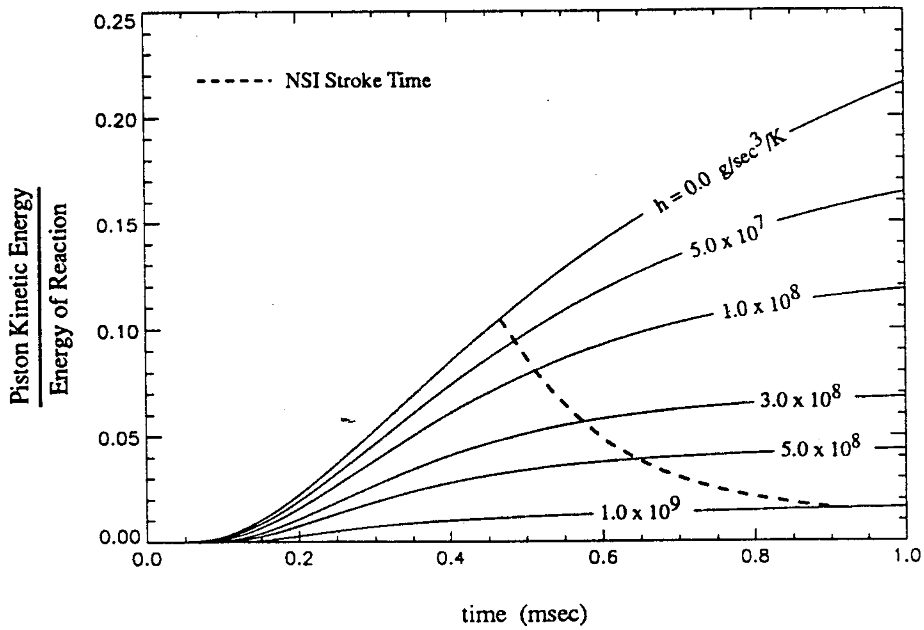


Heat Transfer Sensitivity Study

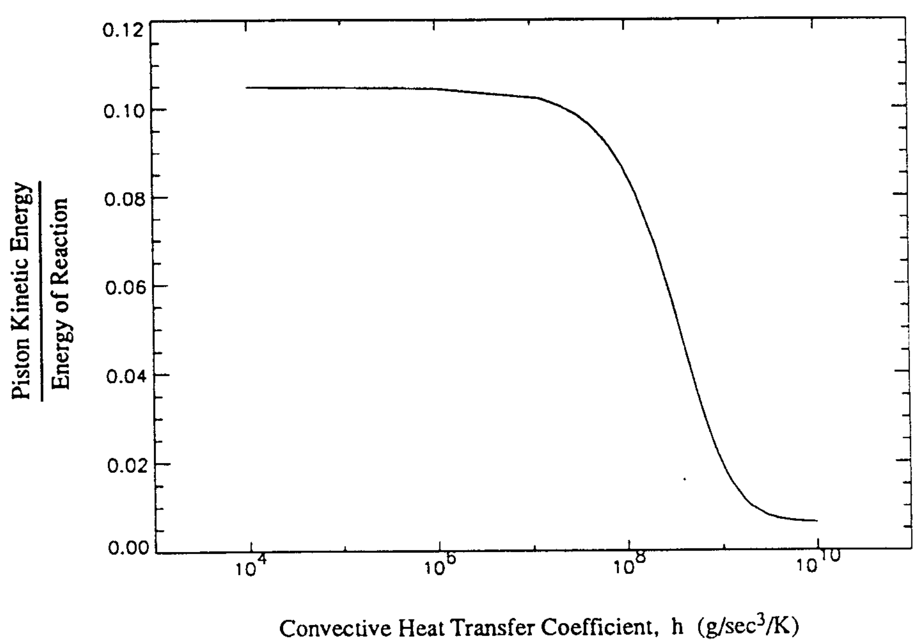
$$\dot{Q}_{in} = \underbrace{hA_w\left[T_w - T_g\right]}_{convection} + \underbrace{\sigma A_w\left[\alpha T_w^4 - \epsilon T_g^4\right]}_{radiation}$$

1. Variations in h.

- kinetic energy – time curve



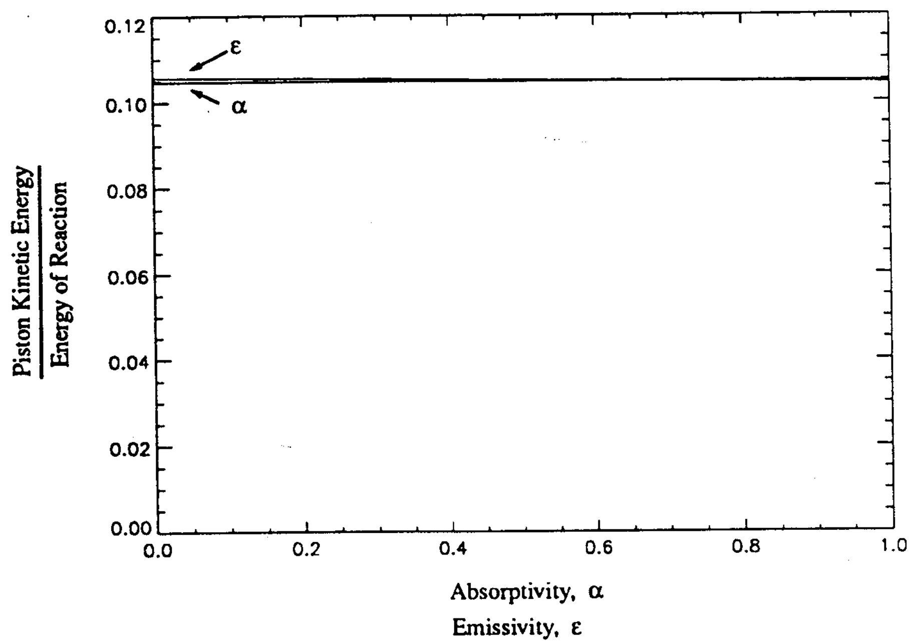
- kinetic energy at completion of the stroke



Heat Transfer Study, cont'd.

2. Variations in α and ϵ.

- kinetic energy at completion of the stroke

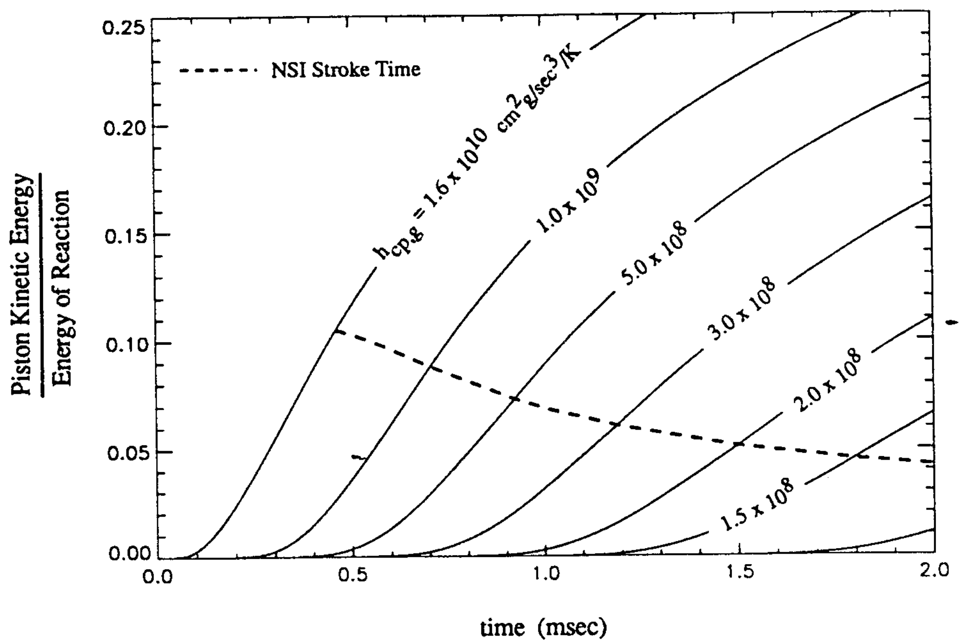


Heat Transfer Study, cont'd.

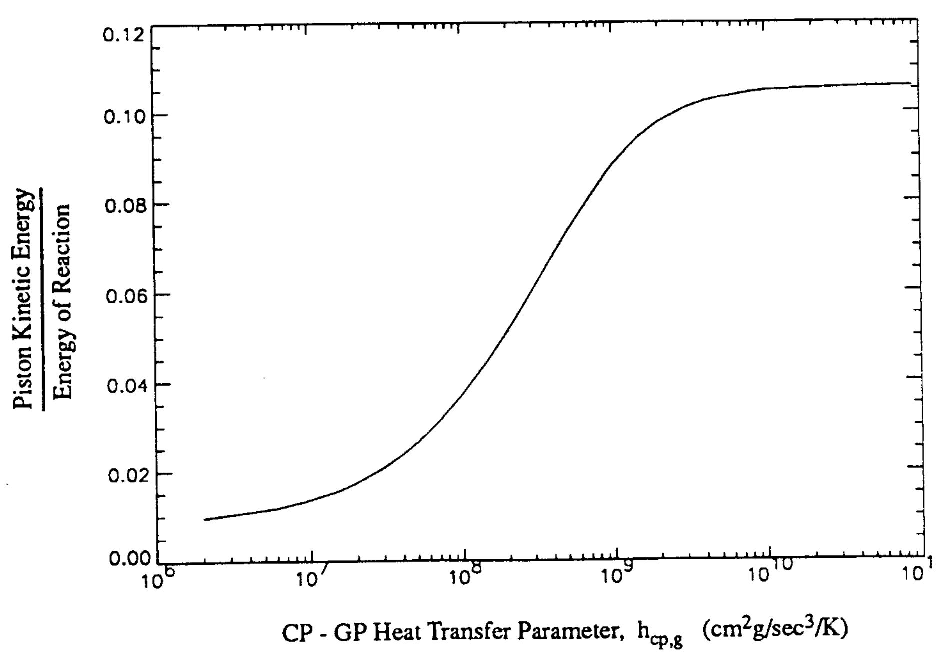
$$\dot{Q}_{cp,g} = h_{cp,g}\left[T_{cp} - T_g\right]$$

3. Variations in $h_{cp,g}$.

- kinetic energy – time curve



- kinetic energy at completion of the stroke



Summary of Results to Date

- Model correctly predicts experimentally observed features:
  - maximum pressure ($\sim 8000\ psi$),
  - velocity of pin at completion of the stroke ($u_p \sim 200\ ft/sec$).

- Model correctly predicts the time scales of events:
  - time of maximum pressure ($\sim 0.10\ msec$),
  - time to complete the stroke ($\sim 0.50\ msec$).

- Sensitivity analysis shows increased model potential:
  - not necessary to provide exact values for various key parameters,
  - predicted solution is insensitive to variations in burn rate for *fast burning pyrotechnics*.

- for peak performance:
  - fast burning rate, $b \geq 1.0 \times 10^{-3}\ dynes^{-0.69} cm/sec$, $n \geq 0.60$,
  - low convective heat transfer, $h \leq 1.0 \times 10^{7}\ g/sec^3/K$,
  - condensed phase products
  - high heat transfer between $cp - gp$ product subsystems, $h_{cp,g} \geq 1.0 \times 10^{10}\ cm^2 g/sec^3/K$. — gas phase products

Outline of Future Directions

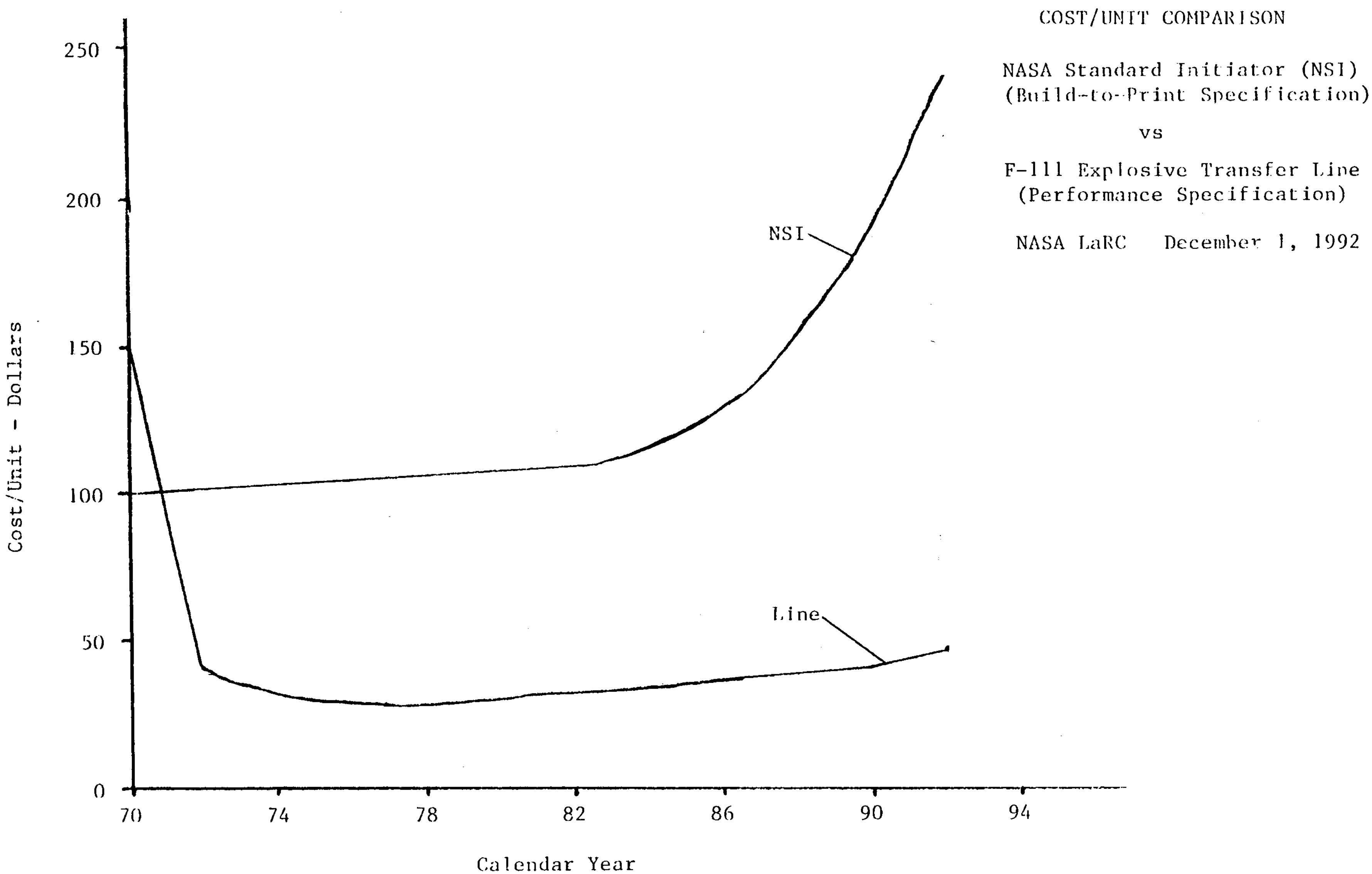
Near Term:

- continue search for accurate burn rate data,
- nondimensionalize model to identify governing parameters (2/93),
- better justify heat transfer coefficients (2/93 – 4/93),
- perform sensitivity analysis for initial conditions (2/93 – 4/93),
- perform sensitivity analysis for larger parameter space (2/93 – 4/93),
- study solution near equilibrium states (5/93 – 7/93),
- include frictional effects (5/93 – 7/93),
- include grain size effects (5/93 – 7/93).

Long Term:

- study spatially resolved field,
- study other pyrotechnic formulations,
- study other geometries,
- study the pyrotechnic ignition problem,
- consider detailed experiments.

ATTACHMENT 20


COST/UNIT COMPARISON
NASA Standard Initiator (NSI)
(Build-to-Print Specification)
vs
F-111 Explosive Transfer Line
(Performance Specification)
NASA LaRC December 1, 1992
NSI
Line
Cost/Unit - Dollars
250
200
150
100
50
0
70
74
78
82
86
90
94
Calendar Year

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A summary is provided for the work performed by the NASA/DoD/DoE Aerospace Pyrotechnics Systems Steering Committee, December 8-10, 1992, including an update on the progress of a program initiated by NASA Headquarters to address pyrotechnic problems. The following projects are discussed: "NASA Pyrotechnic Specification", "PAS Database and Catalogue", "Pyrotechnics Manual", "NASA Standard Gas Generator", "Linear Separation System", "Laser Safe and Arm System/Laser Initiated Detonator", "Service Life Extension", and "Modeling of the NSI Driven Pin Puller".

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